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TEACHERS' MANUAL *(ready soon)*

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Science Education

GREAT TEACHERS OF SCIENCE

I. THOMAS HENRY HUXLEY

JAMES D. TELLER
College of Education, Ohio State University

Thomas Henry Huxley did not of his own free will choose the career which he followed, but rather he was driven into it.[1] His great desire was to be a mechanical engineer,[2] but a medical education was to be obtained more readily. So he was put through the usual medical course, but the only part of the whole course which really and deeply interested him was physiology, "the mechanical engineering of living machines."[3] Perhaps the real force behind this interest was Wharton Jones under whom he took his physiology, and one of the few of his teachers whom he respected.[4] Possibly the low state of English education made this one spark in Huxley's formal instruction glow the more brightly. However this may be, his training fitted him as an assistant surgeon in Her Majesty's Navy. In this capacity he might have been packed off to the West Coast of Africa, but because of the interest of Sir John Richardson, his official chief, he was assigned to the *Rattlesnake* bound on a cruise of scientific exploration. Thus, again did circumstances decide his training. The seven seas became his laboratory, and the current low status of knowledge would have made even superficial observations of extreme importance. As it was Huxley was a rather keen observer, and so his investigations distinguished him not as a biologist or a geologist, but rather as a naturalist. So scanty was man's knowledge of nature that one man was able to cover the entire field. But collection and species work was a burden to Huxley,[5] making it impossible for the great generalizations of Darwin even to suggest themselves to him. Instead he wished to study the functions of living things. However, England had but one place for a physiologist, professorships. But not even one of these was available for Huxley. So he became a Paleontologist and Lecturer on Natural History.

If it is true that circumstances forced Huxley into a lectureship in the School of Mines, it is even more true that his personal traits prevented these same circumstances from driving him elsewhere. In his time science in E land did not pay. He was able to earn praise but not pudding.[6] During this period of waiting and despair, he more than once made up his mind to throw science to the winds; to emigrate and establish a practice in Sydney where his financée waited for him; to try storekeeping, squatting, or even brewing in Australia.[7] The immediate pressure of circumstances would have forced weaker men to do just this, but not Huxley. He knew that if he were to be happy and satisfied, his life must give scope to his intellectual passion. This decision he announces to his future wife in no uncertain terms:

> I will not leave London—I will make myself a name and a position as well as an income by

[1] Huxley, Thomas Henry, *Collected Essays*, Vol. I, p. 17, New York, D. Appleton Company, 1897.
[2] *Ibid.*, Vol. I, p. 6.
[3] *Ibid.*, Vol. I, p. 7.
[4] *Ibid.*, Vol. I, p. 9.
[5] *Ibid.*, Vol. I, p. 7.
[6] Cf. his letter to his sister as reprinted in Huxley, Leonard, *Life and Letters of Thomas Henry Huxley*, Vol. I, pp. 108–109, New York, D. Appleton and Company, 1901.
[7] Cf. his letter to Miss Heathorn, his future wife as reprinted in *ibid.*, Vol. I, p. 89.

> some kind of pursuit connected with science, which is the thing for which nature has fitted me if she has ever fitted anyone for anything.[8]

Thus, did determination and perseverance prevent circumstances from driving him away from London. But these same circumstances determined his life in London. Year by year, bit by bit, they forced him from original research to original teaching.

Thus it was that Huxley became not only a scientist but also a teacher. But what were the forces, inner and outer, which made him a great teacher? Two such groups of forces need to be emphasized in any adequate appraisal of Huxley. One of these is the development in Huxley's thinking of a passionate love for veracity not only in his own life but in the lives of others, of an uncompromising hatred of shams whether in thought or in act.[9] The other concerns the failure of Huxley's time to cherish this principle of truthfulness even with the great improvement of natural knowledge during the nineteenth century, to abhor the prostitution of reason by giving assent to propositions which are neither self-evident nor adequately proved. In this situation Huxley had the "intellect to comprehend his highest duty distinctly, and force of character to do it," [10] if we may use his epitaph upon Henslow as a summary of his own life. This duty which Huxley so clearly comprehended is best given in his own words:

> To promote the increase of natural knowledge and to forward the application of scientific methods of investigation to all the problems of life to the best of my ability, in the conviction which has grown with my growth and strengthened with my strength, that there is no alleviation for the sufferings of mankind except veracity of thought and action, and the resolute facing of the world as it is when the garment of make-believe by which pious hands have hidden its uglier features is stripped off.

Because of these objects he subordinated "any reasonable, or unreasonable, ambition for scientific fame" to other ends:

> to the popularization of science; to the development and organization of scientific education; to the endless series of battles and skirmishes over evolution; and to untiring opposition to that ecclesiastical spirit, that clericalism, which in England, as everywhere else, and to whatever denomination it may belong, is the deadly enemy of science.[11]

Since it is upon his efforts to attain these objects that his greatness as a teacher depends, it is imperative that we investigate the means which he employed in fostering his ends.

The secret of Huxley's greatness as a teacher is to be sought not so much in his own intense love of pure knowledge, as in his ever increasing desire to apply that knowledge in the guidance of the lives of other people. As a scientist he was a master because he himself had learned to use a key for unlocking the knowledge of nature; as a teacher he was a genius because he early learned how to instruct others in the use of this key. While Huxley engaged in little formal study of the psychology of learning, his practices show a keen understanding of its fundamental principles. In the choice of his content, in his organization, and in his methods of presentation he anticipated much that is best in twentieth century education.

In the selection of material for his lectures, Huxley was at all times conscious of his audience. His breadth of learning taught him that in any one lecture or course of lectures it was impossible to cover everything. Yet he had learned from Faraday to suppose no knowledge on the part of his audience.[12] His aim at all times was to take up a fruitful idea and bring it home to everyone. All of his lectures involved an immensity of labor, but this is especially true of his lectures to workingmen. In the preparation of the latter he felt a great responsibility, and did not like to make scientific statements which he had not personally verified by experi-

[8] *Ibid.*, Vol. I, p. 91.
[9] *Ibid.*, Vol. I, pp. 233–239.
[10] *Ibid.*, Vol. II, p. 427.
[11] Huxley, Thomas Henry, *op. cit.*, Vol. I, pp. 16–17.
[12] Cf. Huxley, Leonard, *op. cit.*, Vol. II, p. 380.

ment.[13] In his teaching lectures he chose facts which would enable a trained audience to draw its own conclusions. However, in his public lectures he passed rapidly over the facts and put forward his own personal convictions.[14] Thus, his public addresses sometimes gave the impression of being largely impromptu. But Huxley carefully thought out every word that he intended to say and would not entrust exactness to the inspiration of the moment.[15]

Not only in his lectures, but also in his articles and books, Huxley shows his ability to select that which was best fitted for his purposes. In his *Practical Biology* he selects a few animals and plants to serve as types of living things. This plan is in marked contrast to the desire of some modern writers of biology texts to cover the entire field. Perhaps no text will illustrate Huxley's powers of selection better than his *Physiography*. The material for this book is taken from the whole field of physical science to satisfy the child's first questions concerning nature. The text on the Crayfish likewise shows a judicious selection of material. Because of his care in choosing his facts, writing was indeed weary work for Huxley.[16] He suggests his method of writing in a letter to Romanes as follows:

> My own way is to write and rewrite things, until by some sort of instinctive process they acquire the condensation and symmetry which satisfies me. And I really could not say how my original drafts are improved until they somehow improve themselves.[17]

Moreover, he insisted that other people should give more attention to their composition. Thus, at the dinner given in honor of the twenty-fifth anniversary of the founding of *Nature*, he scolded the young fellows sharply for their slovenly writing.[18] Again on suspecting a lack of knowledge on the part of a certain writer, he advises him as follows:

> Lock up your essay. For two years—if possible, three—read no popular expositions of science, but devote yourself to a course of sound practical instruction in elementary physics, chemistry, and biology.
>
> Then reread your essay; do with it as you think best.[19]

At another time, in a letter to Parker concerning his "frog paper," Huxley writes as follows:

> From a literary point of view, my dear, dear friend, you remind me of nothing so much as a dog going home. He has a goal before him which he will certainly reach sooner or later, but first he is on this side the road, and now on that; anon, he stops to scratch at an ancient rat-hole, or maybe he catches sight of another dog, a quarter of a mile behind, and bolts off to have a friendly or inimical sniff. In fact his course is . . . (here a tangled maze is drawn) not —.[20]

By such frank criticism he hoped to improve the literary style of his scientific colleagues, and thus add this advantage to the side of the proponents of scientific education.

Not only did Huxley exercise care in the selection of his material for articles, books and lectures, but he also gave much thought to the organization of that which he had selected. It would be difficult to find better illustrations of a combined psychological and logical treatment of a subject than in the writings of Huxley. It is in this respect that his *Physiography* is radically different from recent attempts to construct elementary introductory texts on

[13] His son credits Huxley with never making a statement in his regular lectures which he had not personally verified by experiment. While this was his ideal, it is improbable that he always achieved it. For this reason the more conservative statement has been employed. Cf. *ibid.*, Vol. II, p. 441.

[14] Cf. his reply to Father S. J. Hahn's query as to why he did not even mention evolution in his class lectures on comparative anatomy while in his public lectures he openly proclaimed himself an evolutionist. *Ibid.*, Vol. II, p. 428.

[15] Cf. his conversation with Professor Osborn, *ibid.*, Vol. II, p. 440.

[16] Cf. his own statement, *ibid.*, Vol. I, p. 171.

[17] *Ibid.*, Vol. II, p. 42.

[18] Cf. *ibid.*, Vol. II, p. 414.

[19] *Ibid.*, Vol. II, p. 417.

[20] *Ibid.*, Vol. I, p. 447.

physical science. While using a psychological approach, he always ends with a logical integration of his subject. The separate facts are not given for their own sake, but for the relation which they bear to the whole thought. While certain modern texts have improved and extended the psychological approach, few of these even suggest a unified view. But if Huxley's knowledge of psychology was narrower than that of his modern progeny, his knowledge of scientific method was so much wider that he perceived the worthlessness of an array of facts, however practical they might be. He saw that which the modern progressives have refused to see: that a psychological organization alone cannot teach scientific method for it is not the method of science.

No small part of Huxley's influence as a teacher is due to his blending of the psychological with the logical. For this reason a detailed illustration of his method will not be out of place. His speech to the workingmen of Norwich "On a Piece of Chalk" [21] shows his method at its best. In his psychological approach, he begins:

> If a well were sunk at our feet in the midst of the city of Norwich, the diggers would very soon find themselves at work in that white substance almost too soft to be called rock, with which we are all familiar as "chalk".

Then, branching out, he continues:

> Not only here, but over the whole Country of Norfolk . . . and, on the seacoast . . . northward . . . on the south coast.

Still the circle widens:

> Chalk occurs in northwest Ireland, . . . France . . . Denmark and central Europe . . . North Africa . . . Crimea and in Syria . . . central Asia.[22]

Then follows a superb example of the correlation of knowledge. The chemistry of chalk, its mineralogy, the biology of the origin of chalk, its geology coupled with the origin of the earth, and finally evolution, philosophy, and scientific method are unfolded in a way that his audience of workingmen could not only understand, but enjoy. With a small beginning he leads them to a great ending.

In his correlation of knowledge Huxley is aided by the historical treatment. In this connection it is well to note that this is the method which the folk high schools of Denmark have found so well adapted to adult education. To continue our illustration from the address on chalk, he makes the chalk tell its own history, for he believes that a great chapter of the history of the world is written in it. Listen to his own evaluation of such history:

> I weigh my words well when I assert, that the man who should know the true history of the bit of chalk which every carpenter carries about in his breeches-pocket, though ignorant of all other history, is likely, if he will think his knowledge out to its ultimate results, to have a truer, and therefore a better, conception of this wonderful universe, and of man's relation to it, than the most learned student who is deep-read in the records of humanity and ignorant of those of Nature.[23]

The essay "On the Formation of Coal" [24] as well as many others exhibits the same high regard for the historical treatment. Moreover, the historical approach with Huxley is not merely a brief historical preview of the subject, as we find in many modern science texts; it is an integral part of the method of organization.

Not only in his public lectures, but also in his class lectures, Huxley employed a psychological approach and an historical correlation of knowledge. In class lectures on biology he would take a representative type of the animal or plant world and correlate all the principles of living matter to it. This method is just the opposite of that used by some modern texts on biology of relating the principles to many representative animals or plants.[25] Instead Huxley

[21] Cf. Huxley, Thomas Henry, *op. cit.*, Vol. III, pp. 1–36.

[22] *Ibid.*, Vol. III, pp. 1–2.

[23] *Ibid.*, Vol. VIII, p. 4.

[24] *Ibid.*, Vol. VIII, pp. 137–161.

[25] One such text relates the principles of the biologic sciences separately to many plants and animals. Thus, there are separate divisions on taxonomy, distributional biology, morphology, physiology, genetics, ecology, and behavior. Cf.

would take a lobster or a crayfish or a frog and show the application of the principles of physiology and morphology to its functions and structure. This is well illustrated in his own discussion of the proper way to study zoology.[26] After warning his audience not to be content with dry definitions, Huxley recommends that they take "some concrete living thing, some animal, the commoner the better," and see how it inevitably leads into all branches of science.[27] Here there is a very definite insistence on both psychological and logical organization. We are to begin with the known and lead to the unknown, but we are also to correlate these facts.

Huxley selects the lobster as the type upon which to develop his model organization. The development of unfamiliar terms is first made by actual observation of the specimen. Nor is there a mere cataloguing of parts. After drawing the parts, he relates them to the general problem of the modification which they have undergone. Thus, he induces the student to use his knowledge in a problem. After this functional treatment, Huxley leads his students more definitely to the historical: "Our lobster has not always been what we see it," [28] so a study of development follows, leading to the proof of the doctrine of unity of plan. Then is presented a superb example of the correlation of knowledge: "I have hitherto spoken as if the lobster were alone in the world," [29] but he has many relatives and friends, and is surrounded on all sides not only by strangers, but actual enemies. A study of the facts of distribution leads to a study of habits, and this in turn to the facts of physiology. Thus does each fragment of the organism lead us into vast regions of thought.

Perhaps the most salient feature of Huxley's organization of biology is the method of teaching by types. This system has been put into practice by Professor Rolleston at Oxford even before Huxley used it.[30] It is interesting to note, however, that while Rolleston began with the more familiar type of animal, Huxley used the microscopic forms as his introduction when the method was put into operation at South Kensington. But as Huxley tells us, "the experience of the Lecture-room and the Laboratory" taught him, "that philosophical as it might be in theory, it had defects in practice." [31] So the course was reversed, and began with the more familiar type of the frog. This change illustrates Huxley's willingness to sacrifice logical organization in favor of one more fitted to the abilities of his students.

If a large share of Huxley's greatness as a teacher depends on his judicious selection of subject matter and on his ability to correlate the familiar with the unfamiliar, a still larger share must be attributed to his methods of presentation. These consisted largely of the lecture and demonstration. As to the relative part played by each and the method of their use, we shall let him tell us what was done in his biological laboratories at South Kensington:

> There I lecture to a class of students daily for about four-and-a-half months, and my class have, of course, their textbooks; but the essen-

Kinsey, Alfred C., *New Introduction to Biology*, Chicago, J. B. Lippincott Company, 1933. Another text unifies these separate divisions by relating them to the energy concept. Cf. Curtis, Francis D., Caldwell, Otis, W., and Sherman, Nina Henry, *Biology for Today*, New York, Ginn and Company, 1934. However, by far the larger number of modern biology texts present the subject matter in isolated "units and problems" and make no attempt to logically relate these. One of the more recent texts uses Thorndike's principle of impressiveness and selects its illustrations from the dramatic element of biology. Huxley would accuse such a text of teaching the students to look for the facts of biology "elsewhere than under their noses." Cf. Baker, Arthur D., and Mills, Lewis H., *Dynamic Biology*, New York, Rand McNally and Company, 1933.

[26] Huxley, Thomas Henry, *op. cit.*, Vol. VIII, pp. 196–228.

[27] *Ibid.*, Vol. VIII, pp. 199–200.

[28] *Ibid.*, Vol. VIII, p. 204.

[29] *Ibid.*, Vol. VIII, p. 206.

[30] Huxley, Leonard, *op. cit.*, Vol. I, p. 406.

[31] Huxley, T. H. and Martin, H. N., *A Course of Elementary Instruction in Practical Biology*, pp. v-vi, London, Macmillan and Company, 1889.

tial part of the whole teaching, and that which I regard as really the most important part of it, is a laboratory for practical work, which is simply a room with all the appliances needed for ordinary dissection. We have tables properly arranged in regard to light, microscopes, and dissecting instruments, and we work through the structure of a certain number of animals and plants.[32]

Huxley's subordination of the value of his lectures to that of demonstration is in accord with his belief that real scientific training demands first hand acquaintance with the facts. However, his lectures impressed many of his students even more than the laboratory work under his assistants. Of the many impressions of Huxley as a lecturer, the recollections of Henry Fairfield Osborn, who was a student under Huxley at the session beginning in October of 1879, may be taken as representative of the period after Huxley's removal to the new laboratories at South Kensington:

Huxley as a teacher can never be forgotten by any of his students. He entered his lecture-room promptly as the clock was striking nine, rather quickly and with his head bent forward "as if oppressive with its mind." He usually glanced attention to his class of about ninety and began speaking before he reached his chair. He spoke between his lips, with perfectly clear analysis, with thorough interest, and with philosophic insight which was far above the average of his students. He used very few charts, but handled the chalk with great skill, sketching out the anatomy of an animal as if it were a transparent object. As in Darwin's face, and as in Erasmus Darwin's, Buffon's and many other anatomists with a strong sense of form, his eyes were heavily overhung by a projecting forehead and eyebrows and seemed at times to look inward. His lips were firm and closely set, with the expression of positiveness, and the other feature which most marked him was the heavy mass of hair falling over his forehead which he would frequently stroke or toss back. Occasionally he would lighten up the monotony of anatomical description by a bit of humor.[33]

Two examples of the humor to which Osborn refers may well be given. In his description of the mammalian heart, Huxley found that the student had difficulty in distinguishing between the tricuspid valve on the right side and the bicuspid valve on the left. In order to render the task easier, he would remind the student that the bicuspid valve was also known as the mitral valve because of its resemblance to a bishop's mitre. Then he recommended this rule:

You can easily remember that the mitral is on the left, because a bishop is never known to be on the right.[34]

At another time on completing an explanation for a student, Huxley asked if he had made everything clear. To the student's answer that all was clear except one part where Huxley had stood between him and the blackboard, came the rejoinder:

I did my best to make myself clear, but could not render myself transparent.[35]

Osborn's impression of Huxley's ability to chalk as he talked may be supplemented by a description of his lecture drawings as they impressed two of his other students. Professor W. J. Solas, who was a student under Huxley even before the era of the laboratory, tells us that:

The diagrams in chalk, drawn from memory on the blackboard, often as a running accompaniment to a description, shared in the same admirable qualities as the spoken words. They were masterly performances, the cod's skull in particular was a triumph. Those who have watched this sketch growing, as bone was added to bone, until this complex structure stood revealed as a whole and in all its parts, will not soon forget the pleasure with which they watched this notable performance.[36]

Professor Jeffery Parker also felt that Huxley's "blackboard illustrations were always a great feature of his lectures, especially when, to show the relation of two animal types, he would, by a few rapid strokes and smudges, evolve the one into the other before your eyes."[37]

There are at least four other respects in which Osborn's recollections may be sup-

[32] *Ibid.*, Vol. III, p. 284.

[33] Osborn, Henry Fairfield, *Impressions of Great Naturalists*, pp. 75–76, New York, Charles Scribner's Sons, 1924.

[34] *Ibid.*, p. 77.

[35] Huxley, Leonard, *op. cit.*, Vol. II, p. 439.

[36] Solas, W. J., "The Master," *Nature*, Vol. 115, p. 747, May 9, 1925.

[37] Cf. Huxley, Leonard, *op. cit.*, Vol. II, p. 435.

plemented by those of other students. Solas tells us that "Huxley's delivery was sufficiently deliberate" as to enable the student "—aided by occasional interruptions while diagrams were being drawn—to take down his words in full." [38] Professor Angelo Heilprin, also a student of Huxley at South Kensington, notes that Huxley's lectures were delivered with a few notes jotted down on a fly-sheet of paper as his only guide.[39] Professor Mivart was impressed with his patience in answering questions after the lecture was over.[40] The same student also bears witness to the fact that Huxley never used his position as a teacher either to inculcate his own theological views or to depreciate the religious views of his students.[41] Rev. E. F. Russell even felt that "the ultimate result of his words and influence, far from unsettling my beliefs, was to leave me with a new and delightful sense of the greater wonder, wisdom, power, and beauty of creation by evolution than by an act sudden and complete." [42]

These descriptions of Huxley as a lecturer might be multiplied many fold, but most of these would repeat the same thoughts in different words. Perhaps no better summary of the impressions of Huxley's many students could be given than to list the qualities which Osborn finds his lecture notes of Huxley's course to display, namely: thoroughness, forcefulness, clearness, sincerity, and humor.[43] Huxley impressed some of his students with all of these qualities; all of his students he impressed with some of them.

We must not suppose, however, that Huxley's earlier lectures possessed these qualities to the same degree as his later ones. Professor Armstrong, who heard Huxley while he was still at Jermyn Street, was not impressed except by his fluency and drawing. He regarded the lectures as "too didactic" and descriptive without any attempt to display the method of discovery.[44] Even before Armstrong heard him, Mr. Jodrell, a frequenter of the Royal Institution, remonstrated against his lecturing in a colloquial tone, running his words together, and pouring out unfamiliar matter at breakneck speed.[45] Another letter from one of his workingmen also warned him against these qualities. These letters Huxley labeled "Good Advice" and kept as a perpetual reminder. When we compare these criticisms with the comments on his later lectures, we see how much he profited by frank acceptance of criticism and careful practice. He had an object in life, lecturing was an instrument toward its attainment, so he set himself to the task of becoming proficient in its use.

However, even after Huxley had reached the height of his lecturing career, if he was forced to condense, he became quite difficult to follow. This was the situation at Edinburgh when he delivered a summer course of lectures on the whole animal kingdom. Joseph Thomson writes of these lectures:

> One half of the class, which numbers about four hundred, have given up in despair from sheer inability to follow him. The strain on the attention of each lecture is so great as to be equal to any ordinary day's work. . . . And then to master his language is something dreadful.[46]

Youmans also criticized the first edition of *Physiology* because of the compression.[47] Even after Armstrong had heard

[38] Solas, W. J., *op. cit.*, p. 748.

[39] Heilprin, Angelo, "A Student's Recollections of Huxley," *Popular Science Monthly*, Vol. 48, p. 328, January, 1896.

[40] Cf. his Reminiscences as quoted in Huxley, Leonard, *op. cit.*, Vol. II, pp. 437–438.

[41] *Ibid.*, Vol. II, p. 438.

[42] Russell, E. F., "A Student's Reminiscences," *Nature*, Vol. 115, p. 752, May 9, 1925.

[43] Cf. Osborn, Henry Fairfield, "Enduring Recollections," *Nature*, Vol. 115, p. 726, May 9, 1925.

[44] Cf. Armstrong, H. E., "Huxley's Message in Education," *Nature*, Vol. 115, pp. 743–744, May 9, 1925.

[45] Huxley, Leonard, *op. cit.*, Vol. I, pp. 94–95.

[46] *Ibid.*, Vol. I, p. 476.

[47] Huxley, Thomas Henry, and Youmans, William Jay, *The Elements of Physiology and Hygiene*, p. 4, New York, D. Appleton and Company, 1876.

Huxley at his best, he still felt that he was never "a direct teacher of scientific method, though, by implication ever its greatest advocate." [48]

Notwithstanding the usual excellence of Huxley's lectures, he was probably correct in attributing greater weight to the demonstration as an instrument of scientific instruction. In his own teaching at South Kensington, he would give a daily introductory lecture at ten o'clock.[49] The students would then report to the demonstrators in the laboratory for two hours before lunch and two more after lunch.[50] The laboratory staff included at different times such men as the future professors Foster, Rutherford, Geddes, Lankester, Parker, Lawson, Howes, Dyer, and Vines. Under the direction of the demonstrators, each student dissected a specimen of the subject dealt with in the lecture.[51] Professor Parker tells us that "the naive astonishment and delight of the more intelligent among them was sometimes almost pathetic." He relates how "one clergyman, who had for years conducted classes in physiology under the Science and Art Department," on being shown a drop of his own blood under the microscope exclaimed, "Dear me! it's just like the picture in Huxley's *Physiology*." [52]

In his demonstration work, Huxley not only provided the students with the facilities for individual dissection, but also arranged a small working museum close to the laboratory. This contained "elaborate dissections preserved in spirit, and models of various organisms in successive stages of their development." [53] On the walls of the laboratory he had "many beautiful coloured diagrams, the work of Mr. G. B. Howes." [54] A large share of the demonstration work was left to the demonstrators. Huxley, himself, seldom came through the laboratory, so that, as Osborn relates, his visits "inspired a certain amount of terror." [55] In this connection it is well to note that Huxley had few personal contacts with his students. His teaching was largely of an impersonal character. Perhaps this may be attributed to his own strenuous researches and to the thorough preparation which he gave to his lectures.

The philosophy of education which Huxley evolved during his attempt to make science known to the masses has exerted a profound effect on contemporary educational thought. While he was not the first to visualize a unitary system of education, his statement of this conception as a ladder reaching from the gutter to the university was so graphic that others used it to express that which they thought but could not say so well.[56] Thus, Huxley's

[48] Armstrong, H. E., *op. cit.*, p. 745.

[49] Both his son and Rev. Russell tell us that the usual time was ten o'clock, but Osborn gives the time as nine o'clock. Cf. Huxley, Leonard, *op. cit.*, Vol. II, p. 436. Also, Russell, E. F., *op. cit.*, p. 751.

[50] Sir Thiselton-Dyer says that the laboratory work continued from 11 a.m. to 1 p.m. and from 2 p.m. till 4 p.m. Cf. Thiselton-Dyer, W. T., "Plant Biology in the Seventies," *Nature*, Vol. 115, p. 711, May 9, 1925. Professor Vines, however, says that two hours were devoted to laboratory work in the morning and two in the afternoon. Cf. Vines, S. H., "The Beginnings of Instruction in General Biology," *Nature*, Vol. 115, p. 714, May 9, 1925.

[51] Cf. Russell, *op. cit.*, p. 752.

[52] Huxley, Leonard, *op. cit.*, Vol. I, p. 407.

[53] Russell, E. F., *op. cit.*, p. 752.

[54] *Ibid.*, p. 752.

[55] Osborn, Henry Fairfield, *Impressions of Great Naturalists*, pp. 75–76, New York, Charles Scribner's Sons, 1924.

[56] As late as the year of Huxley's death we find many versions of Huxley's statement of the ladder conception quoted by educators in America. Thus, during the meeting of the National Education Association in 1895, "the late Professor Huxley," is quoted as follows: "I believe no educational system in this country (England) will be worthy of the name of national, or will fulfill the great object expected of it, unless it be one which establishes a great educational ladder, the bottom of which shall be the gutter, and the top of which shall be those universities of which we are justly so proud." Cf. Ely, Richard T., "The Future Organization of the Higher Education in the United States," *Journal of Proceedings and Addresses of the National Education Association*, p. 653, 1895.

phrase became an instrument for the popularization of the ideal not only in England but also in America.

Huxley was also a force in the promotion of universal education because of his efforts to broaden the scope of education. He exercised a powerful influence in the movement to fit the school to the needs of all the people by the recognition of new subjects of study. Not only science, but also drawing, manual training, domestic economy, and physical drill are greatly indebted to him for their introduction in the school program. He was instrumental in the establishment of new types of education as an integral part of the school system. Infant schools, continuation classes, and higher technical schools owe a great deal to his efforts. However, Huxley realized that the mere addition of new subjects and new schools to the old ones without a parallel improvement in the existing institutions could not realize his ideal of a liberal education. The enslaved subjects could not be freed by mere association with the free ones. So he centered an attack on the gerund-grinding and formalism of the classicists, and exposed them as debasers of the noble humanistic tradition which elevated the study of man through literature, history, and philosophy. For this exposure the humanities owe more to Huxley than is usually recognized. His achievement in the liberation of educational thought from the chains which the classicists had forged about it is second only to the part which he played in the liberation of thought in general.

REPORT OF COMMITTEE OF N.A.R.S.T. ON TEACHER PREPARATION

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Herewith is presented a summary of the work of the Committee on Teacher Preparation for the year 1940.

In the committee meeting at the St. Louis convention in February, 1940, it was decided to attack but one phase of the problem, and this is a sub-problem under the larger problem of selection of teachers for preparation to teach science. The sub-problem is that of discovering why teachers who have taught science or are preparing to teach science chose that field as a vocation. It was thought that if we might discover the factors which motivated people in decisions to teach science some contribution might be made to the larger problems of (a) teacher selection for training by training institutions, (b) the better preparation of such a more-carefully-selected group.

The problem of more careful selection of personnel to be entrusted with the teaching of our boys and girls is becoming more and more acute. With an oversupply of poorly-equipped teachers and not-too-good records in the results of their teaching, it is the consensus of opinion that we must raise the qualifications for entrance to the profession. With better practices in preparation, we may then hope for highly increased efficiency in the product which the public schools turn out. Motivations of prospective science teachers are important, therefore, in the particular matter of selecting better teachers. Why do teachers choose to teach science?

The attached questionnaire (in blank form) was prepared to canvass prospective and experienced teachers of science in order to survey their expressed opinions

upon the question of their motivations. By December 20, 1940, 266 questionnaires had been returned to the committee. An analysis of these shows that 180 were from men and 77 from women. (Nine respondents did not specify.) As these were secured from training institutions, it seems evident that more men than women are in training to teach science. Eleven training institutions in various parts of the country are represented in the returns.

Of the 266 individuals 89 had majored in science, as a whole, 48 in biology, 46 in chemistry, 28 in education, 10 in agriculture, 10 in home economics, 9 in mathematics, 5 each in physics, physical science, and social science, with the remainder scattering in English, music, business, and engineering.

One hundred fifty-four had no experience to date in actual teaching, 55 had taught four or more years, with 11, 9, and 11 teaching, respectively, 1, 2, or 3 years. Thus 86 had already had teaching experience.

One hundred thirty-four were working for the bachelor's degree, 100 for the master's degree, and 15 for the doctor's degree.

Discrepancies in accounting for the total of 266 in all of the data submitted are explained through the absence of answers to some of the queries by certain individuals.

There were 155 below the age of 25 years, 50 in the group between 25 and 29; 21 in the group between 30 and 34; and 22 in the group above 35.

Were those represented given the opportunity to make a new choice of a vocation, without restricting difficulties, 118 would still choose teaching; 33, medicine; 14, research in science; 9, engineering; with smaller numbers for agriculture, aviation, army, laboratory technician, chemist, art, music, nursing, and the like. These choices are generally closely related to the subject matter of science or one of the sciences. It is apparent that a good many are not thoroughly interested in teaching school boys and girls.

In the data concerning motivations, therefore, interpretations must always be made in the light of the character of those who responded to the questionnaire items.

It is to be noted that each person rated the suggested motivation 0, 1, 2, 3, or 4, depending upon whether he considered it of no importance (0) or of great importance (4) in his decision to be a teacher of science. These ratings were grouped by institution and by the total group to find the distribution of frequencies of these 0, 1, 2, 3, or 4 ratings. For example item 1, "My high school marks in science were very high" as a motivating factor in choosing science teaching as a career had respective frequencies of 65, 22, 54, 89, 39. An examination of these ratings indicates that, apparently, it was not a predominant factor entering into the decision to become a science teacher on the part of a majority of the group although 39 indicated its great importance and 89, its relatively great importance. However, for 65 it was thought of no importance, and 22 considered it of little importance.

Adding the frequencies of ratings 0 and 1 to indicate the relative unimportance of the suggested motivation; and likewise frequencies of ratings 3 and 4 to indicate the relatively great importance—leaving the rating of 2 to indicate a rather neutral position—the sums of 87 and 128 perhaps furnish a better evaluation of the estimations of the total group of those responding. This shows the item as a motivating factor in more cases than not in the ratio of 128 to 87. While not an overpowering majority, the item might reasonably be rated one + or simply + as a motivating factor in the minds of these prospective or experienced teachers.

All items were analyzed in these two ways and the preponderance of opinion expressed by +, ++, +++, or ++++ to show the degree of opinion favoring the suggested motivation. Simi-

larly unimportance was evaluated and expressed by —, ——, ———, or ————, and neutrality by 0. The ratings are shown on the questionnaire.

This analysis gave many more indications of what were non-motivating factors than were motivating factors. The only outstanding motivating factors disclosed in this manner are the items (+ + + +): "I liked to find out how things worked." "I liked to find out why things worked," and in less degree (+ + + or + +). "I particularly enjoyed laboratory work." "I have always liked to experiment." "I liked to work with my hands." "Science seemed to be of such use every day." "I like to talk to people about science." "I like to read of adventures in science." "I liked to work with young people in science."

QUESTIONNAIRE *

The purpose of this questionnaire is to discover why teachers or prospective teachers of science selected science as a teaching field. The factors which entered into your decision are important for guidance and counselling. Your carefully considered responses to the following queries will greatly help in getting valuable data bearing upon this problem.

Will you please rate the following factors entering into your decision to choose science teaching as a career on the basis of a 5-point scale—0 meaning that the factor had no effect in your estimation and 4 meaning that the factor was of the highest importance in helping you to a decision. Place a 0, 1, 2, 3, or 4 on the blank preceding the indicated factor. In the extra spaces provided list any factor or factors which are not mentioned specifically.

+	My high school marks in science were very high.
—	My best marks in high school were in science.
+ + +	I particularly enjoyed laboratory work.
+	I particularly enjoyed lecture demonstration.
0	I liked mathematics.
0	I liked making computations and figuring.
+ + + +	I liked to find out *how* things worked.
+ + + +	I liked to find out *why* things worked.
0	I liked machinery.
+ +	I liked to work with my hands.
+	I liked to handle and manipulate apparatus.
0	I liked animals.
0	I liked plants and growing things.
—	I liked gardening.
+	Science seemed so practical to me.
+ +	Science seemed to be of such use every day.
+	I wanted to understand nature.
+	I loved the out-of-doors.
0	I loved to camp at wild places.
0	I wanted to travel in all parts of the world.
+	I enjoyed greatly my courses in general science.
+	I enjoyed greatly my course(s) in biology.
+	I enjoyed greatly my course in physics.
+	I enjoyed greatly my course in chemistry.
0	Science is full of thrilling adventure.
0	I always thought I'd like to teach science.
0	I was intensely interested in the application of scientific method to living.
— —	I wanted especially to make a contribution to wider use of the scientific method.
+	My philosophy of life is associated closely with scientific attitude.
+ +	I like to talk to people about science.
+ +	I like to read of adventures in science.
0	I think scientific knowledge is the most important of all.
— — — —	My father was a science teacher.
— — —	My father's occupation was associated with machines and science.
— — — —	My father wanted me to go into science teaching.
— — — —	My mother wanted me to teach science.
— — —	My advisor recommended science teaching as a career.

* The entries in the blanks represent the interpreted significance of the items as judged from combined ratings (1+2) and (3+4) explained in the text.

— — — My vocational testing indicated success in science.
— — — My friends advised me to major in science.
— — There seemed more opportunities available in science teaching.
— — — My teacher advised specialization in science.
— — — — It was easier to prepare for science teaching than for engineering.
— — — — It was easier to prepare for science teaching than for medicine or dentistry.
— — — I expected to teach only temporarily and science was my favorite.
+ + I liked to work with young people in science.
+ + + I have always liked to experiment.
— I liked to consider a life of research and discovery.
0 I believed scientists are the greatest benefactors of mankind.
— — — — I wanted to write stories or accounts of scientific discovery.
— — — Opportunity to teach science happened to open for me.
— — — — Opportunities in my profession of.....did not open up.
— — — — A trip I made to a.....made me decide to go into science.
— — — — Recognition I received from.....decided me to go into science.
0 I just seemed to drift naturally into science work.
— — — — I never had any real impulse to do anything else.
— — — — Before deciding to teach science I had worked in.....
0 My interest in.....naturally led me into science teaching.
— — — — I wanted to teach and it didn't matter much what I taught.
— — — — Science is the only thing I ever got any thrill from.
— — — — A relative of mine had been successful in science teaching.
— — — — Admiration for my science teacher induced me to emulate him.
0 I went into science teaching because of my preparation in science.
— — — Science teaching seemed to offer greater opportunities for employment.
— — — — Science teaching seemed to offer greater opportunities for financial reward than other fields.
— — — — Science teaching offered greater opportunity to transfer to the industrial field.

Others receiving a rating of one + indicating some importance are: "My high school marks in science were very high." "I particularly enjoyed lecture demonstration." "I liked to handle and manipulate apparatus." "Science seemed so practical to me." "I wanted to understand nature." "I loved the out-of-doors." "I enjoyed greatly my sources in science (general science, biology, physics or chemistry." "My philosophy of life is closely associated with scientific attitude."

The non-important factors stand out more clearly from this analysis than the important, however. Receiving evaluations of three or four minuses are those factors of influence of: desire to write stories of scientific discovery; lack of opportunity in other desirable professions; trips made to stimulating environments; recognition received in connection with some project; lack of other possible avenues of expression; work in some other field; a stimulating science teacher; desire for financial reward; opportunity to transfer to another field; ease of preparation for teaching; occupation of father or other relative; advice of father, mother, adviser, vocational tests, or friends. Many of these factors are commonly stated as influences which determine vocational choices and it is surprising that those responding to these questionnaire items are so unanimous in their disavowal of these motivating factors. While we must leave some room for doubt regarding this disavowal because the individuals concerned are, after all, merely expressing opinions, yet the fact of such an overwhelming judgment must mean something. If we are to believe the statements, we must conclude that these prospective teachers, on the whole, did not select science teaching as a career because of advice of father, mother, friend or teacher or because of high rating in this field by any vocational test. Nor did they choose it because of financial reward, lack of other opportunity, recognition received, epochal visits to stimulating environments, or other factors listed above. There seems only to be an underlying interest in science as a field of teaching without always a clear

analysis of the elements inducing such interest.

Of course, we must always remember that there are a few individuals who are exceptions to the general run who insist that they were motivated by these influences. But in this study we were especially interested in discovering definite trends among large groups of people.

Does this study contribute anything of help in the solution of the problem of better selection of teaching personnel for science teaching?

It seems to indicate that students who select science teaching as a career do not do so because of primarily self-centered reasons, nor because of advice received but because of some underlying interest in its possibilities. If it may be made more clearly a field which attempts to explain more fully how things work, and why they work that way, it will appeal more strongly than ever to the kind of people who are now in training. Experimentation, laboratory work, manipulation of materials, everyday use, and adventure are features to be emphasized definitely. People interested in these features are those who are choosing science teaching as a career. Find people who are interested in these features and they will exemplify more nearly the peculiar abilities represented by science as a field. Emphasize these features in order to interest larger groups. Then elimination of those unfit to be entrusted with close instructional association with our boys and girls will be in order. A good teacher must be one who has qualifications beyond mere interest in science. Wise leadership and guidance of boys and girls are qualifications which must be investigated. These are suggestions which seem indicated by the data obtained.

Tabulations of the responses by teachers of chemistry, or biology, or physics, or general science might disclose further differences than already disclosed but the committee has delimited its considerations to the broader group of science teachers as a whole. Certainly there must be differentiating reasons for teachers choosing chemistry rather than biology; or physics rather than general science. And, undoubtedly, there are further reasons why persons wish to specialize more narrowly or are more interested in what we call general education. The place of specialization versus generalization is a much-discussed question right now.

More comprehensive data of the sort collected might well be analyzed with reference to differences in men and women, experienced and inexperienced teachers, differences in institutional reaction, differences in geographical location, differences in age groups, and so on. Current efforts to amalgamate the sciences for general education are pertinent considerations. As time goes by our philosophy of science teaching will revamp itself by virtue of such analyses. With a more clearly delineated philosophy we can be more sure of better means of selection and the preparation which follows. We are not yet ready for great stabilization in procedure. Flexibility is the wisest provision at present, it seems. We still have much to do in defining science as a teaching field for elementary, high and collegiate levels before we may be sure what a good science teacher is. Then we may better select prospective science teachers and plan more wisely for more thorough preparation. In the meantime we may emphasize interest in how and why things work, laboratory techniques, and experimentation as outstanding interests of teachers of science.

A SUGGESTED SUBSTITUTE FOR COMPREHENSIVE EXAMINATIONS IN UNDERGRADUATE COLLEGES

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It appears to be quite generally accepted that some kind of a comprehensive review of a part or all of the work of the four years of college is distinctly desirable near the close of the senior year. In most cases this review, more or less well done, culminates in a so called comprehensive or general examination covering the work of at least the last two years.

However an inquiry, continued over a period of four years, into the present status of the examinations as they are being given in several institutions, reveals certain fundamental differences of opinion. Even among those who consider that an examination is a valuable and necessary conclusion, there is little agreement on such important points as the time to be allowed for review or the plan to be followed. There appears even less agreement on what constitutes a "comprehensive" examination or the time which should be allowed for writing it. The nature of the examination, whether it shall be oral, written, or a part oral and a part written, is also in many cases a matter of personal opinion. These points of difference exist, not only among the various departments which differ widely in subject matter, but even among those whose work is of like nature where we might expect to find a greater uniformity because of the similarity of the material to be considered.

A second factor indicated by the study is that there is a minority, but still a considerable minority of persons engaged in education who feel that we already have far too much stress placed on formal examinations, and that as many of the "comprehensives" are at present conducted, they constitute merely one more series of endurance tests which adds little or nothing to results which can be secured by a properly correlated and comprehensive review without an examination.

It should be possible for each department, or a group of related departments, to develop a plan of review including study, reading of additional material, or experimentation if desired, which will bring to the student all the values obtainable from such a review without culminating in an experience which in itself is of doubtful benefit to any student and which may be of real harm to some.

For one student who will continue with graduate or professional work, most of our colleges are graduating many who will not do so. For that one, it is possible that the experience of taking such an examination may have some slight value, since he is likely to encounter other comparable ordeals in the future. On the other hand, the student has been subjected to similar two or three hour tests several times a year for nearly four years, and it would appear that this should have given sufficient practice in answering questions and solving problems for any probable benefit to be obtained in this way. If efficiency in this respect has not yet been reached, it is highly unlikely that one more examination will accomplish that end.

While the present suggestion is primarily for the larger group, those not planning on graduate work, it is sufficiently flexible to allow adaptation to the needs of the student who has further academic work in view. The plan was designed for the small college in which each senior can be given as much personal attention as may be desirable either by the director of the department concerned or by other members

of the departmental staff with training broad enough for the work involved.

It presupposes a teaching load such that it will allow time for individual work with as many students as may be majors—to use an old but still familiar term—in the department. It also presupposes a willingness on the part of the teacher to devote time and thought to giving necessary aid in planning the review and finding material, as well as an ability to refrain from giving unnecessary aid. No two students are likely to have had identical courses, so that each must be considered as an individual case. This, at least, has been the experience of the writer in the four years in which the plan has been in operation in the biology department of a small college.

What, then, we may ask, are some of the benefits to the student of such a summarizing of the last two years, or better still, of all four years of more or less intensive labor? The following are suggested:

1. To impress upon the student that "courses" are not separate entities but that all knowledge is a "related whole." This is not a new idea but one which has been present in the minds of many teachers who have long realized that to be of the greatest value such correlation should be carried on throughout the entire college course. However it can be emphasized more effectively in retrospect when the work of the four years is nearing completion.

2. To stimulate the power of recall, not of minute details, but of fundamental principles around which the courses have been built, so that the student may become aware that what are seemingly different lines of education are nevertheless developed on the same basic principles.

3. To give practice in reading with critical mind, books and articles not always primarily scholastic, but which are of a type that will be met with frequently in the future; to teach the sifting of wheat from chaff, or the good from the less good in daily reading. Earlier reference reading has usually had as its aim the acquiring of basic knowledge which is essential before the student can have a foundation for critical judgment. Now there is need for practice in building on this foundation.

4. To make it possible for the student to obtain at least a general knowledge which will fill gaps in an otherwise well selected course, by reading, experimentation, or other devices—correlating links as it were.

5. To increase the power of observation and to carry it into daily life. Heretofore this ability has been applied largely in relation to individual courses. Now the student should be better able to see, not only interrelations among these courses but also relations to phases of life to be met outside the limited realm of the college.

The plan developed may be discussed under two heads: (A) Working Outline and (B) Recording Results.

Working Outline

1. The student is asked to select a pivotal topic which in some special way represents individual interest. This may be a recent book, some experiment, or even an object closely related to the major interest. Whatever it is, it functions chiefly as a starting point about which the review may be planned. As a typical case we may mention a student who was interested in aviation and who had taken the work offered in the college aviation courses to the point of solo flying. She chose the book, *Sand, Wind and Stars* by Exupery. After reading the book she selected from it four references of particular interest to her and which led to definite correlation with four of her courses. These were (a) French—the author is French; (b) Ecology—description of a forced landing in the desert, and other descriptions of the topography of the region over which the author flew; (c) History of Religion—experiences of the author among the Mohammedans; (d) Aviation—construction of planes and the materials used in them.

2. Having made the selection of references and related courses, the student is now asked to review notes, outlines, or whatever she may have as records of these courses. In some cases where it is certain that she will later have other references to the same course, she may be advised to review only a part of the course at this time.

3. The student will then select from any source available such as books, magazines, or by experiment, something which will give her additional material on the course

or part of the course involved. This must not be anything read or done for her regular work. The above student might continue the topic of deserts of her ecology course by reading *Deserts on the March* by Paul B. Sears. The topic aviation might be continued by reading *Air and Its Mysteries* by C. M. Botley. The subject French might lead to a search for material on the life of the author of *Sand, Wind and Stars*, or to something in French related to some other course, as *Conferences de Palcobotonique* by Paul Bertrand. When books are selected they may or may not be read in entirety at this time depending on the plan of the book. Magazine articles are read entirely.

4. In all readings or experiments, the student will watch for some connection to another course. For example in connection with airplane construction she may find reference to physical laws. This will at once bring to mind a course in physics. She may decide to read *The Star Gazer: The Life of Galileo* by Harsanyi, which will in turn lead her to history during the sixteenth century. This will be done for each of the four original topics and continued until all courses of the junior and senior years have been included once or several times. The sequence will then be as follows starting with the pivotal topic and each of its four references: pivotal topic-reference to course-course review-reading-reference to course-course review-reading, et cetera.

In addition to or in place of some of the reading, the student may well visit industrial plants, museums, exhibits, or other places for special study.

5. Conferences are held one hour a week, but the student is free to ask for help more frequently if it is needed. At each conference the student reports in writing, the number of hours spent, the number of pages read, the courses reviewed, and any other pertinent information. Difficulties are discussed, sources for material may be suggested, and the fundamental factors in courses and references are considered.

The time requirement has been the same as is expected for a three hour credit course. No credit has been allowed as the work has so far been given, but there is no logical reason why credit should not be given.

RECORDING RESULTS

The device for recording the results has varied but has usually consisted of two distinct parts:

(a) Cards on which the student records all references, one card for each reference. These will include quotations, or a brief summary of the article, and the name of the next course to be reviewed. This has been suggested by the reference; and

(b) A chart or other device on which all references and courses are indicated. This will show at a glance how many times each course has been included in the correlation. Students are encouraged to use original methods of recording data. The cards and chart form a part of the final record deposited with the instructor.

By the time the work is finished all courses have been brought into the correlation and reviewed, they have been connected and related, the knowledge has been increased, and the student has had practice in comparing material found outside of texts with that given in regular class work.

A CASE STUDY OF READING COMPREHENSION DIFFICULTIES IN SCIENCE MATERIALS *

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The importance of reading in a democracy is inestimable. We live in a country where compulsory education for the masses is practiced and where more than twenty per cent of the average total weekly time in our elementary schools is devoted to reading. However, much evidence could be presented concerning the disappointing, if not discouraging, situation with regard to pupil competence in this tool subject. Teachers have generally recognized this situation and are attempting to do something about it.

Monroe and Backus,[1] and others tell us that, although remedial work is imperative, the first step is the diagnosis or discovery of the difficulties underlying poor reading.

The purpose of this study was to attempt to discover some of the comprehension difficulties encountered by a group of eighth grade pupils in reading science material. No attempt was made to determine the causes of the difficulties or to set up a remedial program. It is recognized that a remedial program is necessary before improvement in reading comprehension can be secured, but it is the writer's contention that the discovery of the difficulties is the first step in the remedial program.

Many investigations have been made in the field of reading comprehension. Most of them studied the effect of a previously decided single factor, such as the effect of vocabulary, sentence form, effect of a single reading, and so on. Also many studies speak in terms of group results, using averages and standard deviations. The difficulties of individual students were hidden by these group results. In the few studies which list reading comprehension difficulties, almost no attention has been given to difficulties in science materials.

Since previous studies have been criticized because of their general character, this study was limited to science reading materials and to students on the eighth grade level. It was decided to conduct this study largely on an individual basis in an attempt to discover, by an intensive study of a relatively small number of cases, just what individual difficulties the students were experiencing. It was decided to use a relatively small amount of reading material and to test it thoroughly by means of written tests. It was hoped that this method would give a more thorough knowledge as to the ability of students to read with comprehension.

In selecting material for reading selections the following requirements were set up:

1. The material must contain meanings and concepts which require careful, inferential thinking.
2. The material must lend itself to various methods of testing.
3. The selections must not be of such length as to make it impossible to test on them exhaustively and not so short that they do not give the child an opportunity to read on a single topic for a reasonable length of time.

After examining science materials in magazines, government bulletins, reference books, and text books, it was decided to use material taken from *Everyday Problems in Science* (revised), by Pieper and

* Article based upon Master of Arts thesis, unpublished, The State University of Iowa, 1940.

[1] Monroe, Marion and Backus, Bertia, "General Principles of Diagnosis of Reading Difficulties," Chapter II in Remedial Reading. Boston: Houghton Mifflin Company, 1937.

Beauchamp.[2] The material consisted of three different selections, each approximately 400 words long, all dealing with the general topic of transportation. Selection A concerned the automobile; Selection B, concerned ships; and Selection C, concerned the airplane.

The following types of tests were prepared for each reading selection: vocabulary, factual true-false, inference true-false, multiple-choice and completion. The vocabulary test was used to see if the students had knowledge of the meaning of key words in the reading selections. The factual true-false test was used to see how well students could secure verbal facts from the selections. The inference true-false tests were used to determine the students' ability to make inferences from the facts tested in the factual true-false questions. The multiple-choice test was used in order to make use of another measure of pupil's ability to secure verbal facts from the selections read, and also, to make certain inferences from the facts found in the selections. The completion test was used to give students an opportunity to answer questions in their own words.

The tests were given to the one hundred forty-two eighth grade science students in the Ottawa, Kansas, Junior High School where the writer teaches general science. All scoring was done by the investigator. This was thought desirable especially in the case of completion questions where judgment was necessary in determining whether the answer was correct.

Scores which students made on all of the science reading tests were correlated with the scores which they made on the Iowa Basic Skills Reading Test. This correlation was made as a check on the validity of the science reading tests. The correlations ranged from .414 to .708. It is believed that these correlations were high enough to indicate that the writer's tests were reasonably valid measures of reading ability.

It was impossible to classify all the reading comprehension difficulties experienced by the students. It is very difficult to attempt to discover objectively really what a student's difficulties are when he cannot comprehend reading material. A student may indicate, by his response to a question covering a given item, that he does not comprehend the item. But this inability to respond correctly may be due to faulty test construction. The student may understand the material but not the question covering the material. But even if we could be reasonably sure that the student was experiencing comprehension difficulties, we would still have the problem of discovering what the specific difficulty was.

It was the purpose of this study to discover some of the comprehension difficulties which eighth grade students experience in reading science material. Many difficulties were encountered by the students in comprehending this science material as indicated by their answers to the questions over the selections. These difficulties, which are listed below, may not be the most important ones and are probably not the only ones encountered by the students. However, the difficulties listed are, in the opinion of the writer, outstanding difficulties in reading comprehension.

1. Vocabulary difficulties
   a. Using two words interchangeably, with different meanings. The words car and engine were used interchangeably by several students.
   b. Difficulties with variations in word meanings. Words many times have more than one meaning. If the meaning which a word has in a given statement is not the same as the meaning the student is familiar with, difficulty in comprehension will result. In the reading selection on ships the

[2] Pieper, Charles J. and Beauchamp, Wilbur L., *Everyday Problems in Science*, (revised). New York: Scott Foresman and Company, 1936.

word "knot" was used to mean the nautical mile and also to mean the tie formed with rope. Several students experienced comprehension difficulties because of this word "knot" and its two meanings in one reading selection.

c. Difficulties with single words. If the key word in a sentence has no meaning for a student, little comprehension of the sentence can result.

2. Difficulties in connection with punctuation marks. This difficulty applied only to the underlined portion of the following statement in Selection B, where students failed to observe the second comma: "The log, when used in connection with *the compass, furnishes a rough estimate of the ship's position,* but this method is always checked by means of other more accurate instruments." When asked what the compass was used for several students answered, "The compass furnishes a rough estimate of the ship's position."
3. Difficulties encountered from erroneous statements in previous questions. Incorrect responses to previously answered mutiple-choice questions accounted for most of these difficulties. A few erroneous true-false statements were repeated as true statements. For example, students were asked why Columbus had no idea of how far he had traveled. One student replied that he forgot his instruments. This was the answer which this student had chosen on one of the multiple-choice test questions.
4. Difficulties encountered from reading previous selection. The word "screw" was used in Selection B in in reference to ship's propellers. The word "screw" was used in Selection C in connection with wood screws. The word "propeller" was used in connection with a ship in Selection B and in connection with an airplane in Selection C. The use of the same word in two different situations caused confusion in the answers of several students. Several students gave perfectly sound statements in answer to certain questions, but the questions were answered by answers that did not apply to the given question. For example: several students told what the "log" was when asked to tell how it was used.
5. Verbalism or the insertion of words regardless of what they say. Students in many cases found a group of words in the reading selections which seemed to them a fitting answer to the question and, therefore, answered the question by inserting these words regardless of what they said.
6. Number difficulties. These difficulties in which students had trouble in comprehending ideas were where numbers were involved. Some students apparently do not have an adequate concept of numbers. An examination of the case studies revealed that some of the students were unable to discriminate between 6, 60, and 600 miles per hour; and between 1,500 and 15,000 revolutions per minute.
7. The reading of past experiences into answers. This was a difficulty experienced by several students. It is hard for students to withhold past experiences. Students were told in Selection C that the air causes a parachute to open as it falls. The question was asked, "What causes a parachute to open?" Several students gave the answer that the rip cord is used to open the parachute. There was nothing in the reading selection about a rip cord, so it is believed that the association between

the words "parachute" and "rip cord" had been previously formed.

8. Previous opinion difficulties. Instead of checking to find answers about which they were sure, the students wrote down what they thought to be the correct answer. One student when asked, "At what speed must a car motor be running before the car can be started?" answered that "it had to be running around five miles per hour." Obviously this is nothing more than an opinion or possibly a guess.
9. Difficulty in putting words together to make sense. This is different from the verbalism difficulty in that under this classification, students were unable to construct a sensible statement. Under the verbalism classification, many statements were good sound statements but had nothing to do with the question asked. The following is an example of a student's inability to put words together to make sense. The question was asked, "What part of a balloon is used to assist in making a good landing?" The answer given was, "The part that is to hold the gas is to be made good."
10. Wandering attention before an idea is complete. Some students started an answer but had forgotten what they intended to say before the answer was completed. For example, the question was asked, "How does the ordinary mile compare with the nautical mile?" An answer given was, "The ordinary mile is shorter than the ordinary mile." This student apparently forgot what he meant to write after he started writing the answer, hence the disagreement between the two parts of the sentence.
11. Inattention to certain words or phrases in certain statements. If certain key words in a statement are completely ignored, comprehension becomes increasingly difficult. Many examples were found in this study in which students ignored certain words in the questions and also certain words and phrases in the reading selections. For example, students were asked to describe the first instrument used in determining the distance a ship had traveled. One answer was, "It is the log." In this example, the word "describe" was completely ignored.
12. Difficulty with detailed statements. Some students were apparently able to grasp the total meaning of a statement but experienced difficulties with details concerning the statement. This fact becomes more significant when it is remembered that this was not a recall test but a test on which students could check back for details if they had been forgotten. In one question students were asked to describe the log. One student answered, "It consisted of a stick of wood attached to a rope." This is true as far as it goes, but the log must have several other parts in order to determine the speed of a ship.
13. Evasion of question or inability of student to give a definite answer. Some students apparently are unable to give a direct answer. Perhaps it was because they are unable to decide on a definite answer. This question was asked, "Do most cars have the same kind of gear shift device?" Instead of answering that most cars do or most cars do not have the same kind of device, several students countered with an answer that "some cars have a different kind of gear shift."
14. Difficulty in organization of ideas. This was a very common difficulty. Students apparently had an idea concerning the answer to a question

but had trouble in organizing the answer. As an example, students were asked to "describe the log." The following answer shows organization difficulties: "It was a rope with a piece of wood every 50 feet and they counted them every minute to see how far they had gone."

15. Inability to make inferences or do deductive reasoning. There are more cases of difficulty listed under this classification than under any of the others. It is not contended that this is the most important reading difficulty, but merely that more cases were placed under this heading. This may be due to the fact that certain test questions were constructed to test the student's ability to make inferences. The following example is a good sample of a student's failure to do deductive or inferential thinking. This question was asked: "Why can a balloonist not change the direction of his flight?" One student answered, "A balloonist cannot change the direction of his flight because there is no way of telling in what direction they are traveling." This infers that he could change the direction of his travel if he could find out what direction he was going.
16. Unclassified difficulties. It was impossible to classify all reading comprehension difficulties which were discovered in this study. It is very difficult to discover objectively just what a student's difficulties are when he cannot comprehend reading material. When it was impossible to classify a difficulty, it was placed under the unclassified heading.

CONCLUSIONS

As shown by the results summarized above, this study revealed that many types of difficulties appear in reading comprehension. Furthermore, such difficulties are found only through a careful study of the actual responses made by individual pupils. One cannot depend upon total scores on tests or measures of central tendency and variability to reveal these various difficulties because the difficulties of individual students are hidden by group results.

This study supports the conclusion that many types of test items should be used or at least that one should always consider the possibility that a pupil may be credited for having a certain knowledge by one type of test item, yet fail to reveal the command of such knowledge when responding to a different type of item.

It was the purpose of this investigation to discover by a case study method, the comprehension difficulties of eighth grade students in reading science material. No attempt was made to study the causes of the difficulties nor was an attempt made to set up a remedial program. It is recognized that a remedial program is necessary before improvement in reading comprehension can be secured, but the discovery of the difficulties is the first step in the remedial program. After the difficulties have been discovered, it then becomes the duty of teachers and administrators to work out remedial programs which will have for their purpose the elimination of these comprehension difficulties. The discovery and listing of such difficulties is only the first step in planning a remedial program in reading.

RECOMMENDATIONS

1. The various meanings of key words essential to comprehension of the material being read must be given special attention.
2. Students must be taught to observe punctuation marks in reading science material.
3. When erroneous concepts are presented to students in the form of true-false and multiple-choice test items, time should be taken later to present the correct concepts.

4. Students must be given more opportunity to express ideas in their own words in order to do away with verbalism—the rote-learning of answers.

5. The development of adequate number concepts should not be left entirely to the arithmetic teacher. Time should be spent in developing adequate concepts in connection with related science materials.

6. Before reading science material on a foreign topic, time should be profitably spent in finding out what some of the concepts are which the students have concerning the material to be read.

7. Students must be given ample opportunity for practice in organizing material read.

8. Students must be made to realize that reading is the getting of meaning from the printed symbols and not the mere pronouncing of words.

9. More training in following directions could profitably be given to students.

10. Since a mastery of isolated facts does not insure understanding of material, perhaps less time should be spent on the mastery of facts and more time spent on organizing isolated facts and in building up meaningful concepts concerning the facts.

THE READABILITY OF SELECTED CONTEMPORARY BOOKS FOR LEISURE READING IN HIGH SCHOOL BIOLOGY*

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THE PROBLEM

During the last ten years many books of a scientific nature have been written for laymen. Some of these have been among the so-called "best sellers" of our time. Though books by such authors as Paul De Kruif, Raymond Ditmars, and Donald Culross Peattie may have become part of the biology teacher's reading, it seems that he has seldom been concerned about their use by the pupils.

In this study it was assumed that (1) the reading of books related to biology is worth while; (2) pupils vary in their ability to read; and (3) it is valuable for the teacher to know the approximate difficulty of a book as well as the content.

The purposes of this study were (1) to determine the relative readability of selected contemporary books for leisure reading in high school biology; and (2) to provide biology teachers with suggestions based upon the above findings.

Readability was interpreted as meaning the ease of comprehending a book as determined by sentence-length and the number of different hard words. Hard words were words not common to both Thorndike's list of the most commonly used one thousand words and the International Kindergarten Union's word list.

Thirty-five books published between 1931 and 1939 were chosen from the *Standard Catalog for High School Libraries*[1] and *By Way of Introduction*.[2] These two sources were used since the books in-

*An abstract of a Master's thesis, Rutgers University, 1940.

[1] Cook, Dorothy, Cowing, Agnes, and Monro, Isabel. *Standard Catalog for High School Libraries.* New York: The H. W. Wilson Company, 1937. 979 p. (Also the 1938 and 1939 supplements.)

[2] The American Library Association and the National Education Association. *By Way of Introduction.* Chicago: American Library Association, 1938. 130 p.

cluded in them represented selected lists already chosen for high school use.

A search through various studies revealed that only a few of these thirty-five books have been investigated in regard to their readability. For example, Alfred Lewerenz directed a number of federal projects which determined the readability of over five thousand books. Only seven of the above thirty-five books were included in his investigations. Therefore, the problem of determining the relative readability of these books seemed worth while.

DETERMINING READABILITY

The method that was used to determine readability in this study was chosen from Gray and Leary.[3] Their study revealed the relationship between each of forty-four structural elements and difficulty of reading material. It was seen that the ten elements which showed the highest relationship in order of their potency involved mainly two elements of difficulty; namely, that of sentence-length, and that of ease or hardness of the words.

Two elements, the *average sentence-length in words,* and the *number of different hard words,* were retained for use in the present study for a number of reasons. They ranked first and fifth, respectively, among forty-four elements of difficulty, indicating that they were among the most potent elements. Each of these two elements measured an entirely distinct characteristic of the reading material.

There are 756 words common to Thorndike's list of the most commonly used one thousand words and the International Kindergarten Union's word list. Any word not in this list of 756 "easy" words was considered a "hard" word.

The steps used to estimate the difficulty of each of the thirty-five books were as follows:

1. A paragraph of approximately one hundred words was selected.
2. The number of words, sentences, and different hard words in the passage were counted.
3. The above two steps were applied to ten passages.
4. The number of words, sentences, and different hard words in the ten passages were totalled.
5. The total number of words was divided by the total number of sentences to obtain the average sentence-length in words.
6. The number of different hard words was compared with the total number of words to obtain the average number of different hard words per hundred.
7. Finally, the obtained averages were compared with standards suggested by Gray and Leary.

Of the tables used in the original thesis, only two will be used at this time: Tables III and IV.

In order to compare the two obtained averages of any book in this study with adult books in general, Table III was used. The standards shown concerning the variation of occurrence of the two elements were obtained from a table by Gray and Leary.[4]

According to Gray and Leary, "easy" adult books were about as difficult as most fourth and fifth grade books. "Average" adult books were no more difficult, structurally, than the average reading text for sixth grade and junior high school. No grade equivalents were provided for the "difficult" and "very difficult" areas.

This method of determining readability was applied to the thirty-five selected books. The results are shown in Table IV. The books were listed alphabetically by the authors. However, in Table IV, the authors' names were omitted in order to conserve space in the table.

It may be seen that the book *American*

[3] Gray, William S., and Leary, Bernice E. *What Makes a Book Readable.* Chicago: The University of Chicago Press, 1935. 358 p.

[4] Gray and Leary, *op. cit.,* p. 282.

Bird Biographies had an average of 26.1 words per sentence and 19.1 different hard words per hundred. A comparison of 26.1, the average number of words per sentence, with the standards for this element showed that the book was "difficult." However, 19.1, the average number of different hard words per hundred, indicated that the book was "easy." Considering both of the structural elements, the book was listed as "average."

TABLE III

STANARDS FOR DETERMINING THE AREA OF DIFFICULTY

Structural Element	Areas of Difficulty			
	Easy	Average	Difficult	Very Difficult
Number of different hard words in a hundred word paragraph				
Range	25.5–12	33.2–12	36.2–20.6	37–19.3
Upper quartile	21.9	26.5	30.9	33.7
Median	20.3	24.3	28.6	31.1
Lower quartile	16.9	22.1	26.8	28.2
Average sentence-length in words in a hundred word paragraph				
Range	27.1–13.3	38.5–13	44.4–20.1	74.5–34.1
Upper quartile	21.1	25.8	31.8	42.8
Median	19.1	22.8	28.5	40.0
Lower quartile	17.7	20.4	25.8	35.5

The majority of the books (twenty-one out of thirty-five) were in the area "average" or were no more difficult structurally, than the reading texts provided for the junior high school. These books were of approximately the same difficulty as adult books in general as investigated by Gray and Leary. Six books were "easy," six were "difficult" and only two were "very difficult."

Merely to say that a book belongs to a certain area of difficulty does not provide a complete picture of the difficulty of a book. A more vivid conception of these areas of difficulty may be obtained from a perusal of sample paragraphs found from Gray and Leary.[5]

DIFFICULT AREA

Among the many popular delusions that are always with us there is none more persistent than the current misapprehension about Africa. It still seems to be believed that considerable areas of the once dark continent remain practically unknown to whites, that it is difficult to "penetrate" the remote interior, that one still blazes trails and visits places and peoples hitherto unknown. Returning travelers from Central Africa are hailed as explorers! Yet this is a delusion which could easily be dispelled. One glance at a collection of modern colonial maps would show the heart of darkest Africa as it is today—a rapidly developing commercial frontier perfectly well known, thoroughly explored, occupied and everywhere open to transportation.

By rewriting the content of the above passage, with attention directed upon sig-

[5] Gray and Leary, *op. cit.*, p. 247.

TABLE IV

THE FREQUENCY OF THE OCCURRENCE OF THE TWO STRUCTURAL ELEMENTS AND THE AREAS OF DIFFICULTY OF THE BOOKS INVESTIGATED

Title of Book	Average sentence-length in words	Average number of different hard words per hundred	Area of difficulty
American Bird Biographies	26.1	19.1	average
Bob Becker's Pet Book	20.	27.2	average
Half Mile Down	32.6	30.6	difficult
Pasteur, Knight of the Lab	19.9	27.9	average
The Wonder World of Ants	17.5	19.1	easy
On Jungle Trails	20.3	21.3	easy
Wilderness Wanderers	19.	30.	average
The Long Road	20.9	26.7	average
Attaining Manhood	27.1	29.1	difficult
The Fight for Life	23.2	30.2	difficult
Men Against Death	20.2	26.2	average
Seeing the Unseen	17.6	22.	easy
Confessions of a Scientist	19.9	30.9	high average
The Making of a Scientist	19.4	26.6	average
Wild Animal World	26.3	25.7	high average
The Insect Man	26.1	22.9	average
Alcohol, Its Effects on Man	35.4	32.6	very difficult
An American Doctor's Odyssey	22.7	28.7	high average
The Horse and Buggy Doctor	16.8	24.2	easy
100,000,000 Guinea Pigs	30.3	33.9	very difficult
The Island of Penguins	30.	22.6	average
Insect Allies	18.4	21.6	easy
Vanishing Wilderness	19.9	27.3	average
Behold Our Land	20.2	29.8	high average
Green Laurels	25.3	27.7	difficult
Singing in the Wilderness	21.6	24.2	average
Leaves	23.6	34.	difficult
Audubon	22.2	26.4	average
Animal Treasure	20.2	26.4	average
Grassroot Jungles	18.2	29.2	average
Strange Birds and Their Stories	32.8	27.	difficult
Chanco	15.3	22.3	easy
Salar the Salmon	25.4	25.	average
Twenty Years Under the Sea	18.1	29.7	average
Exploring with the Microscope	25.4	25.6	average
Medians	20.9	26.7	"average" area

nificant elements, Gray and Leary obtained the selections below. The same thought was involved, but the difficulty was reduced.

AVERAGE AREA

It is not uncommon for certain false ideas to be believed so persistently that they become popular. A case in point is the popular belief that Africa is still a dark continent with large areas quite unknown to white men. People who cherish this idea believe that it is difficult to penetrate far into the interior of the country, that one still blazes trails and visits places and people never known before. They hail returning travelers from Central Africa as explorers. Such ideas need not persist. One glance at a collection of modern

colonial maps would quickly establish their falsity. These maps show the heart of darkest Africa as it is today—fully explored, perfectly well-known, occupied, and everywhere open to transportation.

EASY AREA

People living in one country frequently have wrong ideas about another country. One of our most popular ideas is that Africa is still a dark continent as it was years ago before white men explored it. Many people believe that the only way to enter the center of Africa is to blaze a trail through the forests. So they look upon travellers from Central Africa as explorers. Ideas like these could be quickly changed by a glance at a collection of modern maps. They show that even the heart of darkest Africa has been fully explored and that everywhere the country is open to transportation. Africa is too well-known and too far developed to be called a dark continent.

Illustrations of the "very difficult" area were omitted. Gray and Leary pointed out that a person capable of comprehending a difficult book will have no additional serious difficulty understanding reading material classified as "very difficult" according to structural elements, unless the thought of the material is more involved.

The grade equivalents of the areas "easy" and "average" and the sample paragraphs of the various areas should provide a means by which the area of difficulty of each of the thirty-five books can be interpreted.

CONCLUSIONS

The conclusions of this study are:

1. The thirty-five books ranged in difficulty from "easy" to "very difficult."

2. The majority of these books investigated belonged to the area "average."

3. The books of "average" difficulty were suitable for most tenth grade biology students.

4. The area of difficulty of each book as determined by this study coincided with the grade placement given by Lewerenz [6] and with the recommendation given by the *Standard Catalog for High School Libraries,* where such comparisons could be made.

5. In consideration of Conclusion 4, which involved fourteen different books, it is probable that the areas of difficulty of the thirty-five books as determined by this study may be relied upon as a guide.

[6] Los Angeles City School District. *Books Evaluated by Means of the Vocabulary Grade Placement Formula.* 1937. Also the 1938 and 1939 supplements. 75 p. each.

ART AND SCIENCE: A METHOD

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Educators believe that the adolescent rarely masters the scientific method of study. Critical judgment is usually a level of thinking that comes after years of patient learning.

But as far down as the first grade one finds children who have qualities of being methodical and critical. Their activities can hardly be placed in the category of science, but their determination and perseverance on many occasions invoke the praise of those whose business it is to know.

We understand that experiments have a lasting effect on children. All youths have endured trial and error, some have even formulated secret rules for profiting by their mistakes. Perhaps one does not wish to credit youngsters with such maturity, but careful observation of their activities in many cases will show this to be true.

The results of child efforts made under experimental conditions are invariably more pleasing to the child than those of haphazard origin. The youngest soon learns the boon of self-help and individual investigation.

In a summer camp recently, where a natural history museum was a center of interest, a seven-year-old child wandered in to attend some lectures on meteorology. For days he sat and watched and listened to discussions of weather instruments and their use. He rarely spoke a word.

One morning the child awoke to find his window covered with moisture. Capitalizing on this natural "canvas," the child eagerly sketched odd figures on the window-pane with his fingers. The light streaming through these passages in the mist carried the colors of the outside world to the receptive personality that fingered the glass.

Becoming thus intrigued by the color, the child was quick to inquire why the moisture did not assume the color of the things outside. To him no explanation was satisfactory. He rejected all. He insisted that if dew forms on the grass and other objects around the house it should take the color of the thing on which it is found. In general he exclaimed, "Water has a lot of colors."

His teacher was so completely confused that the child took his supervisor to the nearby lake to prove his assumption. There on the glassy stillness of the cold mountain pool he pointed at the beautiful reflected colors of trees, rocks, and sky. "See, water does have color. Why not the mist on my window-pane?"

The reward for such astute observations was the promise that even though nature would not color his window, he could. Joy knew no bounds for him, and he could hardly wait for the paint with which he was to work. Don't we usually help where nature fails?

Taking a tin of water color he began to paint on the window. But alas, the paint wouldn't stick. It rolled down in little beads of color. By this time he had a staff of youngsters similarly interested in the problem and its outcome. How were they going to paint the water resistant window? Surely they felt that if dew could stick to the glass they could make the colored paint stay too. One little sage suggested heating the other side. Another thought they could spray it on like rain. And still another, quite naively, thought that they could glue the paint on. The last suggestion brought much laughter but they were determined to try all ways.

The heating method was soon eliminated because no one could suggest a way to heat

the whole window at once and only on one side. Spraying worked crudely and the paint ran in places where it was not wanted. But when the paint was mixed with dry and wet glue (separately) the children found a wonderful new media. They discovered tempera.

The tempera jars were quickly consumed as one child after another sought an opportunity to color a window. No one asked, "What shall I paint?" The whole substance of the experiment demanded that the outside view be transferred to the glass. Their job was to "paste" the world on the window. One after another clouds, trees, and sky settled permanently on once transparent windows.

The pleasantest surprise of all was to see how different the paintings looked from the outside as compared with the inside. This they soon discovered was due to the color being translucent from within and opaque from without. Light and water were new things for young children. They were real because they were discovered.

Skill in painting was never a consideration. The children had no need for standards of composition. They wanted to use matter, they wanted to slap up the windows with color, and they did. Every boy found his own window and a little bit of sky for himself.

How often are children able to work out their own motivation? How often do we permit youth the opportunity of carrying a physical thought out in cultural terms? Can a child in a science class apply his knowledge to art? Or is it not so that our schools divide facts and application in "efficient" bureaucratic fashion? If you learn the nature of a forty-five degree angle can you five minutes later go to work in a miter box? If a child is taught simple proportion how soon afterwards does he apply this information to the idea of enlarging to scale?

Teachers know that there is no single application of scientific concepts. No one way is best for explaining a fact. But we should also remember that for the child there may be only one way. To remember that water is colorless, the little fellow described above had to paint a window, hear strange words at a lecture, watch a reflection in the lake, and ask questions. And this had to be done in succession or he would have lost the iota of correlation we can say he earned.

One cannot hope to have all children understand one example any more than we can expect one child to understand all examples. Ours is the job to know what application is most consistent with the personality of the pupil. In addition the grade school teacher as well as the secondary school instructor should give the youngster an opportunity to carry out ideas in any and all media.

Science is no dictator and we can see, at least in this instance, how a child was able to independently select a program for learning. He was exercising judgment and moving one step closer to the scientific method. The child can point to the road along which a teacher can lead.

SCIENCE EDUCATION FOR ELEMENTARY TEACHERS IN TEXAS TEACHER TRAINING INSTITUTIONS *

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Educators are deeply concerned with the problem of presenting to the elementary school a more carefully constructed science program. The stimulation arises from the fact that seventy-eight per cent of the public school children are in the first seven grades. The field of elementary science has been neglected too long, and there is no doubt that educators are getting at one of the major roots of this problem in studies of teacher education. The purposes of this investigation were as follows:

(1) To determine the professional and academic science needs of students preparing to teach science in the elementary school;

(2) To determine what types of programs the Texas teacher training institutions offer these prospective elementary teachers;

(3) To determine the best suggested programs in comparison with the proposed programs of authorities;

(4) To determine the trends in science preparation of prospective elementary teachers.

It is obvious that before corrective measures may be suggested and comparisons made, existing conditions must be investigated. Courses of study and elementary science textbooks and science readers were analyzed to determine what was being taught in the curricula. In this study four divisions were made to facilitate the grouping of units of similar subject matter content. Two of these divisions were subdivided once.

1. Living things
   a. Animals
   b. Plants.
2. Chemical and physical processes—air, fire, water, magnetism, electricity, sound, simple machines.
3. The Universe
   a. Earth in relation to sun, moon, and stars.
   b. Earth—its rock, soil, contours, physical structure.
4. Interdependence — the relationships between any two of the above divisions.

These divisions were chosen because they parallel the six major sciences, corresponding respectively to zoology, botany, chemistry, physics, astronomy, and geology. The chemistry and physics were not considered separately since it would be extremely difficult to separate the knowledge of these two sciences as employed in units arranged for children in the elementary school. No one field of science will offer information necessary in teaching units stressing "Interdependence"; this information must necessarily accompany a knowledge of the six sciences plus intelligent and related thinking on the part of the teacher.

The units listed in four groups of courses of study were classified and the percentage of material devoted to each division was calculated. Seven Texas public schools had available courses of study for elementary science. Since so few of the public school systems of Texas have developed a course of study, one may assume that the remaining schools follow no regular outline, but leave the choice of content to the individual teacher or have an integrated science program which follows the tentative outline suggested by the State Department of Education. In general, the subject matter suggested in the courses of study of the public schools and the subject matter suggested by the State Department agree closely; in none of the divisions was there a difference greater than four per cent found.

* A summary of a Master of Arts thesis, unpublished, University of Texas, 1940.

As a basis of judging the organization of science in the curriculum in Texas, reference was made to two other sources. The first one was the courses of study of other state departments of education. Ten states were found which included an outline of science units for the elementary school. The other source to which reference was made was the courses of study of thirty non-Texas public school systems in seventeen states.

F—interdependence. The members under the vertical bars refer to the sources: 1—courses of study of Texas public schools, 2—course of study of Texas State Department of Education, 3—courses of study of non-Texas State Departments of Education, 4—courses of study of non-Texas public schools, and 5—pages of elementary science textbooks and science readers. The graph is read as follows:

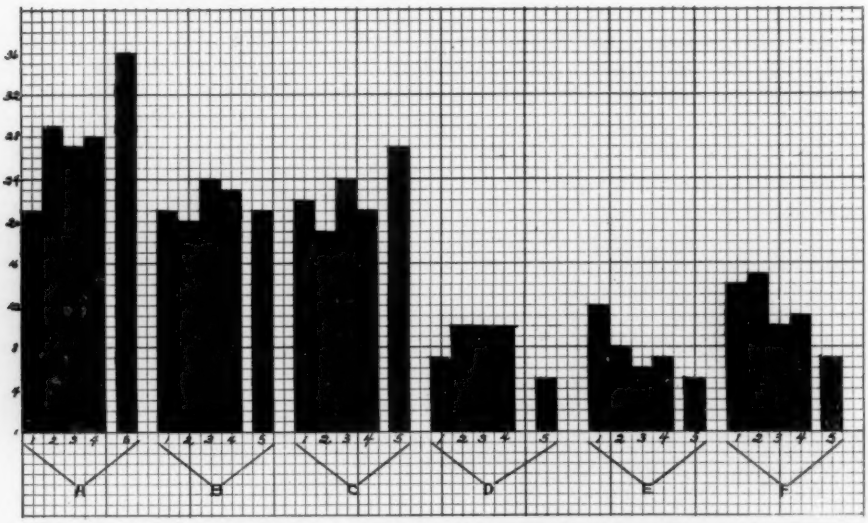

Figure 1.—Percentage Distribution of Various Science Subjects in the Sources Investigated.

The 19,437 pages of student material in the 84 elementary science textbooks and science readers examined were classified according to these same divisions and the percentage of material devoted to each division was similarly calculated.

Figure 1 compares the percentage of material devoted to each division of the subject matter in the courses of study with the percentage of pages of the textbooks and science readers devoted to these same divisions. The capital letters refer to the divisions; that is, A—animals, B—plants, C—chemical and physical processes, D—earth in relation to other planets, E—physical structure of the earth, and

D refers to the material of astronomy, or the study of the earth in relation to other planets. According to the courses of study of Texas public schools, seven per cent of the units were devoted to this material: courses of Education, non-Texas State Departments of Education, and non-Texas public schools devoted ten per cent of their units to this material. However, only five per cent of the 19,437 pages of student material in the science texts and readers pertained to this material.

Two deductions were permissable on the basis of the above data. (1) Agreement was close in the cases of the courses of study; therefore, an approximation of the

science education needed by prospective teachers is indicated by an average of these divisions. The approximate science content of the teacher training program should include the six major sciences in the following proportions: zoology 27.5 per cent, botany 21.5 per cent, chemistry and physics 21.5 per cent, astronomy 10 per cent, geology 10 per cent, interdependence 10 per cent. (2) If the prospective teachers are to present elementary school children with the material of astronomy and geology and with an appreciation of the interdependence and balance manifested in their environment, they will not be able to depend upon the elementary science textbooks and science readers now available. The teacher training programs must obviously include professionalized courses to equip future teachers with the ability to adapt science materials of these divisions intelligently and direct the children in their science activities.

With this information the investigator approached the study of the courses offered prospective teachers of science in the elementary schools in Texas teacher training institutions. Catalogs from thirty-one of the thirty-three senior colleges were examined in view of the four questions which arose: (1) How many institutions included suggestive programs for elementary education students? (2) How much science and what type of courses are offered these students? (3) How many institutions offer special science content courses or special science methods courses for students of elementary education? (4) What type of courses are those which are organized especially for the elementary education students?

Two of the institutions offered no courses in elementary education; therefore, they were eliminated from further consideration. Curricula leading to the B.S. degree in twenty-two institutions and to the B.A. degree in three institutions were offered students who chose elementary education as their major. In the four remaining institutions, this field could not be chosen as a major; however, preparatory work was available.

The following facts were found in regard to the science suggested in the programs of the various schools: one institution recommended fifteen hours of science; fifteen, twelve hours; twelve, six hours; and one institution recommended six hours or no science if the student had had one unit in high school science as entrance credit. Five institutions suggested that a method course in science for the elementary school be included in the teacher training program.

The science courses organized for elementary education majors were offered in one of four departments: education, biological science, physical science, rural arts. Nine institutions offered a total of eleven courses in the department of education. Thirteen institutions offered seventeen courses in the department of biological science, and the same numbers were found in the number of course in the department of physical science. One institution offered a course in the department of rural arts. Of these forty-six courses, only four had been restricted to the obsolescent nature study.

The titles, department, and semester hours of the science and science methods courses for elementary education majors offered in Texas teacher training institutions during the long session of 1939–1940 is given in Table I.

In the 1940 summer session, a variation in the number of courses offered was shown. Two institutions offered eleven courses in the department of biological science. Six institutions offered seven courses in the department of physical science. One institution offered a course in the department of rural arts. With two exceptions, these twenty-one courses had been selected from the forty-six which had been offered during the previous long

session. Cooperating with the Federal and State Agencies directly involved in the conservation movement, seventeen institutions offered a three hour course in conservation during the summer, which had not been available during the previous long session.

Three programs with specific recommendations proposed by different groups or individuals were considered in the pres-

TABLE I

SCIENCE AND SCIENCE METHODS COURSES FOR ELEMENTARY EDUCATION MAJORS IN TEXAS TEACHER TRAINING INSTITUTIONS DURING LONG SESSION, 1939–1940

School	Department In Which Course Is Offered					
	Education	Hours	Science			
			Biological	Hours	Physical	Hours
1			Biological Science	3	Physical Science	3
2						
3			Nature Study and General Science	3		
4						
5			Natural Science	6	General Science	6
6						
7	Elementary Natural Science	3				
8			General Biology	6		
9			Nature Study General Science	3 3		
10	Teaching of Science in Elementary Grades	3	General Science	3	General Science	3
11			Elementary Science General Science	3 3	Elementary Science-Chemical Elementary Science-Physical General Science	3 3 3
12			General Science	3	General Science	3
13			General Science	3	General Science	3
14			Biological Elementary Science Teaching Elementary Science	3 3	General Science	6
15						
16	Nature Study	6				
17	Nature Study	6				

TABLE I—*Continued*

School	Department In Which Course Is Offered					
			Science			
	Education	Hours	Biological	Hours	Physical	Hours
18			Nature Study	3	General Science	6
19						
20	General Science for Elementary Teachers	6	General Biology	6		
21						
22	Science for Intermediate Grades Arithmetic and Science in Primary Grades	3 3	Elementary Science (Department of Rural Arts)	6	Chemistry Survey Physics Survey	3 3
23			Natural History of Plants and Animals	6	Principles of Geography	6
24			Methods in Elementary Health Education	3	Elementary Science	6
25						
26	Nature Study in Lower Grades	6			Teaching of Geography and Elementary Science General Science	3 6
27	Methods of Teaching Nature Study Teaching subjects of Arithmetic, Science, Health, and Nature	6 3				
28						
29	Teaching Science in Elementary Grades	3				

ent study. Palmer [1] has proposed a program for teachers who wish to specialize in science for the elementary grades. Palmer's program was briefly given in this study to emphasize the fact that, in preparing teachers for the elementary school, the difference between preparing science specialists and training regular classroom teachers must be recognized. For a number of years there will be some demand for the science specialist in the elementary school; but if administrators depend alone upon the employment of science specialists, science will never take its rightful place in the elementary school program. No teacher training institution in the state of Texas has arranged its courses of instruction so that a prospective specialized teacher of elementary science could follow exactly the program proposed by Palmer. The professionalized course in Nature Study or Elementary Science recommended is available in forty-five per cent of the institutions. The equivalent for the majors and

[1] Palmer, E. L. "What Constitutes a Desirable Program of Studies in Science for the Teachers in the Elementary Schools?" *Science Education* 15: 101–110; January, 1931.

minors that Palmer has suggested could be obtained in the majority of Texas institutions; however, it would be necessary for the student to devote a longer period of time to some of the courses than Palmer had planned, since he suggested two and four semester hours of work for some courses and three and six hour courses are characteristic of the courses of instruction in the universities and colleges of Texas.

In the *Thirty-first Yearbook of the National Society for the Study of Education*,[2] there is presented a program for the science training of elementary teachers including an orientation course, an introductory course in one of the special sciences, a professionalized subject-matter course, and eight hours of electives in science. No science orientation course was offered in any of the Texas teacher training institutions during 1939–1940. All colleges and universities had made available the suggested introductory course in one of the specialized sciences. The professionalized course recommended was available in all but eight of the Texas teacher training institutions; the electives were available in all institutions.

Vesta Holt [3] has formulated a program which consists of a functionally arranged physical science course, a functionally arranged biological science course, and an orientation-methods of teaching science-course. The recommendations in the program proposed by Holt could be partially met by students in Texas teacher training institutions. The difficulty is that in many of the institutions the courses of the type suggested by Dr. Holt were of three hour value, which indicated that only about one-half of the material she suggested in each course had been included. Only one school offered all three courses which she recommended. Six offered the biological science course; seven, the physical science course; and nine, the orientation (methods) course, that was recommended by Holt.

The trends indicated in the science education of elementary teachers may be summarized as follows: (1) The colleges and universities which have organized professionalized courses for science teachers of the secondary schools have stepped aside and are letting the remaining institutions adopt the task of adequately preparing future elementary teachers; (2) the science departments have recognized the science needs of teachers and have formulated and reorganized courses to meet these needs; (3) the departments of education are cooperating in assuming the responsibility of preparing prospective teachers of science in the elementary school; (4) the more restricted nature study is being replaced by natural and physical science courses, which corresponds to the more rapid replacement of nature study by elementary science, as revealed by the courses of study which were examined.

On the basis of the findings of this study, a program that would furnish the elementary teacher with adequate science education, appears to be a blending of the proposed programs of Holt and the *Thirty-first Yearbook for the Study of Education*. The biological science and the physical science as proposed by Holt would constitute two courses in this program. The introductory course in one of the special fields of science, as proposed by the *Thirty-first Yearbook*, would constitute the remaining six-hour course. The purpose of this course in zoology, botany, physics, or chemistry would be to introduce the student to the special methods of compartmentalized science, which would not have been apparent in the functionally arranged course. A final course proposed for students would be a one-semester course in the department of education. This would stress the methods of presenting science

[2] Powers, S. R. "Programs for the Education of Science Teachers in State Teachers Colleges." *Thirty-first Yearbook for the Study of Education, Part I.* Bloomington, Illinois: Public School Publishing Company, 1932, pp. 325–344.

[3] Hefferman, Helen. "Science in the Professional Education of Teachers for the Elementary School." *California Journal of Education* 6: 100–105; November, 1937.

information to boys and girls of the elementary school. The course would be organized as follows: (1) twelve weeks devoted to study of methods and the preparation of tentative units, (2) four weeks practice teaching in which one of the tentative units prepared by the student would be employed, (3) two weeks devoted to a checking of results and perhaps a reorientation. On the basis of 120 semester-hours for a four year program, science education would constitute seventeen and one-half per cent of the elementary teacher's education according to these recommendations.

THE SCIENTIFIC ARTICLES IN A POPULAR MAGAZINE

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The knowledge of science held by the general public is obtained, to a large extent, from such sources as newspapers, magazines, motion pictures and the radio. In order to find out what is being presented by one of these sources a study was made of the scientific articles appearing in the weekly magazine *Life* for the year 1940. The magazine itself classified articles of this nature as astronomy, medicine, natural history and science. In this paper all of these will be grouped together as scientific articles. Several of the articles were purely descriptive, consisting of pictures of plants and animals. Several were up-to-date reports of research being done by prominent American scientists. Some presented current theories; some were timely when published; many are of lasting interest.

There was a total of fifty-six scientific articles during the year—an average of slightly over one per issue. Thirteen issues contained no such articles, two issues contained three each. During the whole year, 2.18 per cent of the space was devoted to scientific articles and pictures. There was a total of 586 pictures and diagrams—slightly over ten per article. Of the articles that are easily classified, fourteen deal with the physical sciences and forty-one with the biological sciences. Medicine led with seventeen articles, zoology was next with ten. Of the physical sciences, physics and astronomy were given most attention, with five and four articles, respectively. It is noteworthy that some fields were passed over, for example, anthropology, bacteriology, biochemistry, chemistry and geology. Several of the articles did involve some aspect of these sciences, but in every case the emphasis was elsewhere.

Considering the issues for the whole year of 1940, *Life* devoted a respectable percentage of its space to science. The articles were generally timely, always well written and always well illustrated with excellent photographs and diagrams. There was a definite tendency to lean toward the biological side, and especially toward medicine, at the expense of such physical sciences as chemistry and geology. However, when everything is taken into account, it seems that this particular magazine is doing a very good job of presenting to the literate and picture-conscious public a survey of what is happening in the scientific world. Tables I and II summarize the findings of the survey.

TABLE I

GENERAL SUMMARY, *Life* FOR 1940

Number of issues	53
Total number of pages	5436
Total pages of science	118.5
Per cent of total space devoted to science	2.18%
Number of science articles	56
Average number of articles per issue	1.06
Average number of pages per article	2.1
Total number of science pictures	586
Average number of pictures per article	10.5

TABLE II

CLASSIFICATION OF ARTICLES BY SCIENCE SUBJECTS

Subject	Number Articles	Number Pages	Per cent of Space
Physical Science	14	25.5	21.5
Biological Science	41	92.0	77.7
Unclassified	1	1.0	0.8
Astronomy	4	7.0	5.8
Botany	2	5.0	4.2
Industrial	4	8.0	6.8
Mathematics	1	2.0	1.7
Medicine	17	38.0	32.1
Physics	5	8.5	7.2
Physiology	3	5.0	4.2
Psychology	5	14.0	11.8
Zoology	10	22.0	18.6
Miscellaneous	5	9.0	7.6

CONTRIBUTIONS FROM THE BIOLOGICAL SCIENCES TO GENERAL EDUCATION IN THE COLLEGE PROGRAM

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If every college freshman were to become a biologist, a botanist, a zoologist, a physician, a dentist, a pharmacist or a veterinarian, it might then be possible to justify the selection of content of freshmen courses in the biological sciences. Many colleges and universities still offer distinct courses in botany and zoology while some institutions have converted these courses into general biology which in most instances is an attempt to unify the biological sciences. In most colleges and universities the criteria used in selecting content for biology courses are: What new evidence has been found in endocrinology, in cytology, in embryology, in genetics, etc. The fact that a new "pink" eye has been uncovered in genetic experiments upon Drosophila Melanogaster (fruit fly) may be included in lectures to freshmen who hope to obtain a general education. With the exception of students who have a professional interest in biology, students will find such content useless, meaningless and uninteresting. Yet, it is thought by some that these students are obtaining a liberal education or a general education.

A general education cannot be attained unless education is conceived of as a process of growth and effort, like life itself, continuing through life and persisting most effectively in the years after college. Mere memory of isolated facts and an insignificant array of vast factual material is not learning. If education is to imply learning, vital, challenging and interesting problems must be furnished. Furthermore, such data should show a definite functional relationship to man's behavior and to his ability to succeed more efficiently in the process of living.

"Americans are a practical people; the

idea of cloistered halls wherein scholarship can develop for its own sake seems to them almost unintelligible." [1] Yet many college professors and universities still support this type of scholarship for students. The range of concepts of American colleges and universities vary in degree between the two extreme points of view: (1) the "Life-centered" college, independent of prestige and scholar control, where students are free and learn largely or solely by doing and experiencing; (2) The four year, all honors college where courses are prescribed, standardized, and governed by scholars. If the American college is to survive and serve the general public, it should have (a) life and student centered in its concept with the view of developing individuals who can serve society efficiently and thus meet their own needs, (b) a curriculum that offers challenging data of positive value in solving problems of better living, (c) instructors concerned with the intellectual, physical, social, moral, and economic growth of their students rather than with the meaningless informational data that can be obtained from handbooks, (d) the assumption of the responsibility of training its students for jobs and providing necessary experiences that will make a vocational program function, and (e) better relationships between the college and the community.

It is the function of general education in colleges and universities to "advance the public welfare." Since there are approximately 1,350,000 students enrolled in American colleges and universities, who are pursuing courses in the arts and sciences, are we to expect the welfare of our population to be improved? It is indeed worthwhile to strive for such an ideal. Yet, with the curriculum to be found in the typical college of today, it becomes difficult for the writer to conceive of advancing far the welfare of these 1,350,000 students. That the college curriculum needs reorganization, modification, and adaptation to our contemporary way of living has been advocated.[2] A college freshman who is studying isolated courses in English, languages, social science, mathematics and natural science is not automatically prepared to live more fully and richly. Several experimental colleges have attempted to unify their curricula with the hope that the public welfare will be advanced. They have solved the problem partially and until a complete reorganization of the curriculum is in effect, this ideal cannot be achieved.

Nevertheless, each field of human endeavor can contribute materials that can yield worthwhile educational outcomes. It is not claimed that college biology can contribute more towards the development of students than sociology or any other branch of knowledge. Nor does the writer accept the belief that any given subject can do more for the individual than another. Each field of knowledge could make its special contribution to general education. Specifically, general biology for college freshmen and sophomores could do much to enrich their living by helping them solve their problems of social, personal, family and vocational relationships. What job or profession shall I prepare for? How can I keep and improve my good health? What attitudes, interests, and skills can I develop that would yield a fuller life? What contributions can I offer towards creativeness and inventiveness in modern society? What are my problems to be considered in marriage and in rearing a family? Biology in collaboration and unification with psychology, sociology, philosophy, health and physical education can aid in solving these problems.

[1] Cole, Luella. *The Background for College Teaching*. New York: Farrar and Rinehart, 1940, p. 37.

[2] Cottrell, Donald P. "The University and General Education." *Social Frontier*, October, 1938; and O'Rear, F. B., and Linton, C. "Wanted: A College." *Teachers College Record* 41: 124–134; November, 1939.

". . . we have briefly indicated that we may by wise revision and re-evaluation of the subject matter of our curricula in terms of human values do much to improve the effectiveness of our instruction in biology and contribute thereby to a more rational and advanced civilization. . . . If we as individuals would make the most of the opportunities life affords us, skill must be acquired in applying the basic facts of biology to the solution of daily problems that arise in our lives or in those that we may control." [3]

"The ultimate aim of all industry, sciences, government and sociology is for a better life—better living conditions; better health; better food; better government; better houses; in fact, better everything. And these can come about only in proportion as our daily routine and activities conform more nearly to nature's laws, which we understand so poorly at the present time." [4]

These goals may serve to represent the components that make up the function of general education—advancement of public welfare. If the biological sciences are to make any contribution towards the attainment of these gains, it becomes necessary to (1) formulate specific objectives that are based upon the interests, needs, and abilities of the students, the community and society as a whole, (2) select the content for biology that will aid directly in obtaining the desirable goals, (3) use methods of teaching that will yield most efficient and economical learning in terms of the objectives that are set up, (4) evaluate to determine whether or not these aims have been achieved. If any one of these four steps is not well organized or if it doesn't function in accord with the other three statements, the educational outcome will not be realized. Often the first statement (objectives) isn't even considered by college biology teachers, or the objective may be given in terms of learning the basic principles of biology regardless of their social and individual significance to the individual and to society. Where the professor of biology does establish desirable outcomes, failure to attain these goals may be attributed to the malfunctioning of step two or three, or both.

"To assume that the suggested contributions of the biology survey course to the needs of the student in the area of personal living have actually met these needs in a considerable proportion of the student body would be wishful thinking to a rather high degree." [5]

Professors of biology are primarily, and in most cases, solely research workers with little or no training in pedagogy. They lack an interest in knowing what their students think or do or how they think or do their work inside and outside of the college. President Emeritus Neilson has just recently said: "Especially in the natural sciences is it the case that the temptation to early and intense specialization has produced a specialist capable of training other specialists, but ill adapted to educating youth between seventeen and twenty-two." [6] Herein lies a problem that may be solved only through the re-direction of teacher education on the college level. If all of our college freshmen were to become specialists in biology, we would justify the courses given today. Koos [7] shows that less than 10 per cent of the students continue beyond the freshman biology course. Yet, these courses are planned for the pre-medical, pre-dental and those students who will become biologists. About 90 per cent of the students are pursuing a course in biology which has little, if any, meaning to them.

Why should the 90 per cent study this biology when they will not become biologists or specialists who require the knowledge of biology as is offered in most courses today. The reply to this problem

[3] Cockefair, E. A. "Suiting Biological Instruction to Human Values." *Proceedings* of World Federation of Education Associations, 1937. Volume 3, p. 391.

[4] Kettering, Charles F. *Previews of Progress in the Coming Century.* Detroit, Michigan: General Motors Company.

[5] Gilmore, R. C. "The Function of Biology in General Education." Wright Junior College, Chicago, Illinois.

[6] *Bulletin* of American Association of University Professors, Volume 25, 1939, p. 591.

[7] Koos, L. V. *The Junior College.* Minneapolis, Minn.: The University of Minnesota Press, 1924.

can be obtained through a formulation of the objectives of a first year college biology course. These objectives have been carefully defined for biology courses on the secondary school level. Instruction in biology is especially valuable in the realization of six of these objectives, namely, health, worthy home membership, vocation, citizenship, the worthy use of leisure, and ethical character. Ethical character is subdivided into the following aims: to develop many and varied interests, habits, and abilities in the field of science (biology); to develop direct, effective, and satisfying methods of solving problems inside and outside of school; to stimulate the pupil to more direct and purposeful activity; the pupil should gain control of a large body of facts and principles of significance in the home, school, and community. On page 32 of this report [8] the aims of the biological sciences are mentioned, too archaic to be included herein. An analysis of the objectives listed in courses of study in science was made by Beauchamp.[9] These types of objectives mentioned were classified into knowledge, exploration or orientation, abilities, attitudes, ideals and habits, and interests. Of course, one never knew when these objectives were realized, largely due to the inadequate facility for evaluation of the educational outcomes.

Perhaps the objectives of biology might be better understood if they are formulated and if they function as overt behavior or adjustments which a human being should make toward forces about him. Behavior adjustments that could be made as a result of studying biology include: (1) to interpret natural phenomena, (2) to guard oneself against disease, (3) to select food more wisely, (4) to practice the doctrine of good health, *i.e.* (indulge in play or recreational activity, cleanliness, adequate sleep, prevent fatigue, learn how to relax), (5) to care for, grow, and cultivate plants and animals for nutrition and conservation. Other student adjustments that could be made from studying biology as well as from other subjects in the college curriculum are: (1) to consult an expert when necessary (physician, dentists, etc.), (2) to avoid injury, (3) to use tools effectively, (4) to keep alive curiosity, (5) to give information, (6) to prepare for vocations, (7) to address an audience, (8) to participate in social events, (9) to read newspapers and periodicals, (10) to participate in society as a better citizen, (11) to develop hobbies. These supplementary objectives are necessary for efficient living.

Yet, many college graduates fail to adjust themselves satisfactorily. They fail to transfer their academic training to actual problems of living. The problems of living should serve as the basis for the formulation of those objectives, outcomes, or student adjustments and for the selection of the content in biology that will most effectively aid in obtaining these goals.

Biology is the study of life. Such study can contribute more efficiently towards better living only when the teaching of biology becomes functional. The problems of biology are the problems of life and living. "From time to time during the past 15 years, there have appeared in the literature related to instruction in science analyses of problem-solving behavior and of scientific attitudes." [10] The natural sciences, and in particular biology, can offer meaningful and challenging problems. The biological data furnished could aid students to solve some of their problems of living.[11] Yet, this has not been achieved.

One of the objectives in teaching biology

[8] U. S. Bureau of Education. Bulletin 26 (1920), *Reorganization of Science in Secondary Schools.*

[9] U. S. Office of Education. Bulletin 17, Monograph 22 (1932). *Instruction in Science,* pp. 11–12.

[10] Obourn, E. S. and Montgomery, G. C. "Classroom Procedures for Developing the Elements of Problem Solving." *Science Education* 25: 72–80; February, 1941.

[11] Washton, Nathan S. "New Approach to Teaching Science." *Junior College Journal,* April, 1940.

is to enable the student to improve and also safeguard his health. "But in the creation of a scientific habit of mind, and in making the average student biologically conscious in his daily living, our teaching of biology has not succeeded so well." [12] Instead of knowing the causes of a headache and taking the necessary precaution in avoiding headaches, students of biology take headache tablets. This behavior on the part of the students is typical and common with the kind of content to be found in college biology courses. The application of vital principles to toxins, antitoxins, allergy, immunity, disease and sex education are but sample problems that have not been included in the college biology course. One of the questions in an investigation conducted by a committee of the American Association for the Advancement of Science was: "What do you believe are the most significant contributions which a study of (your science) should make to those students who are not to specialize in it?" Taylor [13] found that of the one thousand college and university teachers who replied, more than 80 per cent felt that one of the most important contributions is "to develop the ability to do critical thinking." Taylor states: "I cannot help connecting the favorable attitude toward the critical thinking question with the large agreement . . . that our general courses are not as well designed as they might be to meet the requirements of non-specialists."

The writer may add that our biology courses are poorly arranged, organized and poorly taught for critical, analytical or reflective thinking (problem solving). Two alternatives are offered: (1) modifying the course in biology to conform with the point of view presented in this paper; (2) modify the college curriculum to stress the functional and "unified" aspects.

[12] Cockefair, *op. cit.*, pp. 385–391.

[13] Taylor, Lloyd W. "Science in General Education at the College Level." *Science Education* 24: 241–249; October, 1940.

In the former, biology would offer a series of vital problems pertaining to man and his adjustment. For example, the following outline of a problem [14] might constitute a unit of learning.

HOW DO MAN AND OTHER LIVING THINGS OBTAIN AND UTILIZE THEIR FOOD?

1. Man obtains food from his environment.
   a. diet, plant and animal life, calories
      (1) carbohydrates
      (2) fats
      (3) proteins
   b. vitamins
   c. mineral salts.
2. Plants obtain raw materials that are used for manufacturing their food.
   a. soil and water
      (1) inorganic salts
      (2) fertilizers
      (3) oxygen
      (4) carbon-dioxide
   b. roots and root hairs
      (1) morphology
      (2) osmosis
      (3) how water rises in plants (osmotic pressure, capillarity, transpiration)
      (4) distribution of substances leading to food manufactures
   c. stem
      (1) morphology
      (2) distribution of substances leading to food manufacture
   d. leaf
      (1) morphology
      (2) photosynthesis.
3. Man and other complex animals utilize their food via various metabolic processes
   a. alimentary canal-enzymes
   b. nutrition
      (1) ingestion
      (2) digestion
      (3) absorption
      (4) assimilation
      (5) distribution
      (6) egestion
      (7) respiration
      (8) excretion
   c. animal cell metabolism.
4. Simple plants and animals obtain food from the material in which they live.
   a. amoeba-holozoic
   b. paramoecium-holophytic
   c. spirogyra-holozoic

[14] Washton, Nathan S. "An Effective Approach to Teaching Biology." *Junior College Journal*, November, 1940, pp. 151–154.

d. bacteria-autotrophic and parasitic
e. yeasts and molds-saprophytic
f. euglena-mixotrophic.

5. Other animals than man have special adaptations for obtaining food: spider, grasshopper, butterfly, bee, frog, snake, birds and fish.

Although many values can be obtained from a biology course organized in this way about human problems and adjustments, much of the material to be presented will soon be forgotten by the non-specialist student. It may still be a separate and non-integrated subject.

As a more effective contribution to general education in colleges and universities, the biological sciences should be used only where their contributions will help solve student problems of living. The entire curriculum should be functional and unified. Biology, alone, cannot achieve the broad aim of general education. "How vital a contribution the biological science department makes toward the understanding of social problems depends also upon the social science department," writes Leibson.[15] The writer may add that it depends also upon the psychology, philosophy and English departments, not as isolated departmental courses, but as an integrated, correlated attack upon human problems of living; such is a unified curriculum that will lead to a general education. And as such, biology and other courses can contribute towards a general education in democratic colleges and universities.

[15] Leibson, B. "How the Study of Biology Helps the Student to Understand Modern Social Problems." *School and Society* 48: 356–360; September 17, 1938. p. 359.

EQUILIBRIUM AND HYDROLYSIS: A UNIT IN ADVANCED HIGH-SCHOOL CHEMISTRY

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University High School in Oakland, which serves as the teacher training institute of the University of California, is giving a course in technical chemistry. This course is taken by a selected group of students who have previously had one semester of introductory chemistry and plan to take freshman chemistry later. The course includes the following five units: (1) equilibrium and hydrolysis, (2) qualitative analysis, (3) weight relationships, (4) acids and bases, (5) gas laws.[1] Although it would be desirable to include in the program a unit on thermochemistry (batteries, oxidation and reduction) and an introductory unit on organic chemistry (gasoline, alcohol, organic acids), the available time does not permit such an extension.

The unit on equilibrium and hydrolysis is included in the program as the theoretical foundation for the work in qualitative analysis which is to follow. Moreover, the discussion of equilibrium problems presents an ideal review for a number of chemical reactions which the students learned previously without understanding why the reaction had to be carried out under specific conditions. The intelligent high-school student, however, is just as much interested in the simple mechanism of the reaction as in the reaction itself. In a recent discussion of ammonia with non-selected students, the author explained the Haber process on the basis of Le

[1] The unit herein described was developed by the writer; the other units were prepared by Dr. Laurence F. Foster and Dr. Clyde T. Polson, Supervisors at University High School.

Chatelier's principle. At the end of the period the class expressed the desire to continue the discussion of equilibrium problems rather than go on to the next unit on nitric acid.

The following plan lists the subject matter and the special activities for each sub-unit. Naturally, the main emphasis has to be placed on class discussions, especially since few high-school textbooks contain more than one page on equilibrium and hydrolysis.

SUBJECT MATTER	SPECIAL ACTIVITIES
I. Introduction of the unit.	
1. What is a chemical reaction?	I. 1. Discussion of the kinetic theory.
2. What is a chemical equilibrium?	2. Demonstration: A tube filled with NO_2 at 0° and 100° C. ($N_2O_4 \rightleftarrows 2\ NO_2$).
3. Difference between chemical and physical equilibrium.	3. Discussion.
4. Difference between speed and direction of reactions.	4. Discussion.
II. Speed of reactions. Factors which affect the speed:	II. Sound film (No. 2631 University of California, Extension Division).
1. Temperature.	1. Students' experiments on rate determinations of the reaction between Fe and $KMnO_4$ at various temperatures between 0° and 100° C.[2]
2. Pressure.	2. Discussion.
3. Concentration.	3. Students' experiments on rate determinations of the reaction between KIO_3 and H_2SO_3 at various concentrations.[3]
4. Surface contact.	4. Demonstration: Dissolving of lumps of sugar and granulated in water. Effect of stirring.
5. Catalyst.	5. Sound film (No. 2655, University of California, Extension Division).
a. Accelerating.	a. Demonstration: Decomposition of H_2O_2 with and without MnO_2.
b. Retarding.	b. Discussion of the effect of tetraethyl lead in gasoline.
III. Direction of reactions. Le Chatelier's principle. Factors which affect the direction of reactions:	III. Demonstrations:
	a. Conductivity of conc. and dilute acetic acid.
	b. Equilibrium $CrO_4^{--} \underset{OH^-}{\overset{H^+}{\rightleftarrows}} Cr_2O_7^{--}$.
1. Temperature.	1. Demonstration: Tube filled with NO_2.[4]
2. Pressure.	2. a. Student's report on the Haber process for the manufacturing of ammonia.
	b. Demonstration: Evacuation of a tube filled with a saturated solution of $NaHCO_3$. ($2\ NaHCO_3 \rightleftarrows Na_2CO_3 + H_2O + CO_2$).[5]
3. Concentration. Common ion effect.	3. Demonstrations:
	a. HCl+saturated soln. of NaCl.
	b. $BiCl_3 + H_2O \rightleftarrows BiOCl + 2\ HCl$.
	c. $Fe^{+++} + 6\ CNS^- \rightleftarrows Fe(CNS)_6^{---}$.
	d. Interpretation of data on the solubility of AgAc in the presence of varions ions.

SUBJECT MATTER	SPECIAL ACTIVITIES
IV. Reversibility of reactions.	IV. Students' experiments involving formation of ppts. and gases.
V. Hydrolysis.	
1. Strong and weak electrolytes.	V. 1. Discussion of the theory of ionization.
2. Hydrolysis—reversion of neutralization.	2. a. Demonstration: Decomposition of solutions of $(NH_4)_2SO_4$ and Na_2S.[6]
	b. Students' experiments: Determination of the pH of various solutions of hydrolyzing salts.
3. Buffer solutions.	
VI. Writing of equations: Net reactions involving	VI.
1. Strong and weak electrolytes.	1. Discussion.
2. Hydrolysis.	2. Discussion.
3. Formation of ppts. and gases.	3. Use of solubility tables.

[2] See Briscoe's *A Laboratory Manual of General Chemistry*, 1936, p. 59.
[3] *Ibid.*
[4] *Ibid.*
[5] See Arthur's *Lecture Demonstrations in General Chemistry*, 1939.
[6] See Briscoe, *op. cit.*, p. 71.

Editorials and Educational News

SCIENCE OBJECTIVES OF A MASTER TEACHER

At the Annual Dinner of the Chemistry Teachers Club of New York City last May, tribute was paid to Jesse Whitsit when he was given the Oscar R. Foster Memorial Award for his outstanding services to the teaching of science. Most of our readers know Mr. Whitsit best by the excellent textbooks of which he was a co-author. Some of our readers have experienced the great joy and value of receiving directly from him something of his fine philosophy of science education.

In accepting the award, by Proxy, Mr. Whitsit true to his usual modesty sent a letter in which he shared his honor with other members of the group. The last three paragraphs of his letter express so well his basic philosophy of science teaching that we quote them.

If circumstances had allowed me to be present on this occasion, I would undoubtedly here yield to a temptation to state to many newer teachers, whom I did not have the pleasure of knowing, what it is that I tried, and still try, to stand for. First that, far more than factual matter, the proper objective in all secondary education should be habits, attitudes and ideals, whatever the subject. Second, that since we can find very little in print as to what the significant habits, attitudes and ideals of science are, it is the duty of every teacher who hopes to be a teacher, to observe and speculate until he feels he has the beginnings of knowledge in this matter.

I would probably also be quite unable to resist saying on the point, so often raised when I was in discussion of educational objectives, as to whether or not such things as habits, attitudes and ideals are teachable things, that recent events have thrown much light on the matter. Noting first that uses of mind and all aspects of mental behavior can be very, very bad, as well as good, we now have abundant evidence that evil habits, attitudes and ideals have been inculcated in youth in some lands successfully in degrees that stagger credulity.

In conclusion, while no one can say that the ways of science are the best that humanity might discover, we may well assert that they do represent the very essence of democracy in operation; and also that if ever a tree preeminently proved itself by fruit, that tree has certainly been the science tree.

EVALUATION OF OUTCOMES

It is a long reach for many teachers from factual knowledge objectives to pupil behavior objectives. Not that both types of objectives lack specificity, but rather that evolution in thinking is often a slow process. Time exposure and re-direction of our vision with more time-exposure require time.

We found what to us is a challenging statement about new light on evaluation in the Newsletter of the Commission on Teacher Education of the American Council on Education. It was incorporated in a summary report of the work of the Norris, Tennessee, teachers retreat last spring. The brief quotations below suggest progress or growth in evaluating outcomes.

"At the start of the year," according to the summary report, "we thought of evaluation as a compartment in the school program, quite unrelated to administration, the solution of problems arising . . . in the classroom, and the like. The evidence for this is that evaluation committees (on school objectives like "self-direction," "co-operative living," etc.) were set up as such and were . . . distinguished in nature from other committees. Their job was to be different from, for example, that of the committee to work on the practical problem of loafing in the halls. Furthermore, we set aside one day a week when the evaluation committees could meet on their problems and other days when curriculum and administrative problems could be dealt with in staff meetings. . . . We were, in other words, separating . . . the specific learning situations and experiences, which were supposed to get results in pupils' lives, from the discovery of growth changes evidenced by pupils. . . . Consequently our focus was on instruments rather than on boys and girls."

"Now as time went on, it was noted that the evaluation committees were petering out; some of them never even got started. . . . The staff then began to realize that if evaluation is to get results in terms of actual changes in the school program, it must start with boys and girls as

they behave in specific situations." Stated differently, the need to discover how much progress was taking place in realizing the school's objectives—particularly those having to do with character development—led very naturally to observation of the children themselves and their everyday behavior. Evaluation became child study and *vice versa*.

"Some of our staff feel that this newer and more dynamic approach to evaluation makes real differences in their way of teaching. In this sense, evaluation actually brings about changes in the child's environment (the curriculum) which you can see.

INSTRUCTIONAL MATERIALS FOR DEFENSE

The Information Exchange on Education and National Defense of the U. S. Office of Education is serving as a clearing house for ideas and materials of use in schools. A catalog of 103 listed items may be had upon request. These items have been organized by the Exchange into 24 loan packets comprising publications, posters, outlines, study units, pictorial booklets and reprints of articles. Among the loan packets of interest to science teachers are the following: improving school and community, conserving natural resources, building and preserving health, and understanding the world about us. The materials may be borrowed for two-week periods.

MUSEUMS AND EDUCATION

The growing consciousness of the ways in which museums of various types can supplement school education is one promising symptom of our vision of a greater coordination of community activities for purposes of general education.

One illustration of this educational consciousness on the part of museum officials was the excellent exhibit during July and August at the American Museum of Natural History. The Department of Education of the Museum exhibited especially for teachers various types of material available for circulation to public and private schools through their loan service. Dioramas, miniature history groups, costumed models of peoples of many lands, anthropological specimens, industrial exhibit cases, biological specimens, astronomy cases, and mineral collections were among the types of materials shown.

The exhibit not only revealed to teachers at all school levels the services available at the Museum but provided many suggestions to teachers for preparing their own visual-aid materials.

It does not seem far-fetched in this connection to suggest to supervisors and leading teachers of science that they may be instrumental in their own communities in bringing to the attention of teachers, especially those in the elementary school, the types of materials available for education, whether or not those materials happen to be in a museum.

TEACHER EDUCATION

Newer philosophies and programs for the education of teachers are developing in various centers throughout the country. Three publications have appeared rather recently which indicate directions being taken in this field which is today so significant and crucial to the purposes of education in a democracy.

The first is a pamphlet, entitled *Culture and Personality*: Three Lectures to Educators, published by the Commission on Teacher Education of the American Council on Education. This pamphlet brings together lectures by Ralph Linton, Mary Shattuck Fisher and W. Carson Ryan under the respective titles "Potential Contributions of Cultural Anthropology to Teacher Education," "Children in the World Today" and "The Status of Modern Youth." The second is a publication of the National Teacher Placement Association written by thirty-five of its members and entitled, *Current Practices in Institutional Teacher Placement*. The third publication is a report of the Teacher-preparation program which has been developed at Ohio State University. This book is called *Adventures in the Reconstruction of Education*.

CAN YOU HELP?

Miss Clyde Schuman, 420 Riverside Drive, New York City, is writing a biography of Mary Swartz Rose, until her death last February a member of the faculty at Teachers College, Columbia University, and one of the country's foremost authorities on nutrition. After graduating from Denison University in 1901, Dr. Rose attended Mechanics Institute, Rochester, N. Y., then taught in Fond du Lac, Wisconsin, for three years. She then studied at Teachers College and at Yale. In 1909 she joined the staff at Teachers College, becoming full professor in the department of nutrition in 1921. Miss Schuman will be grateful for letters from persons having notes on her lectures or comments on her educational and scientific procedures; from those who knew her as fellow-student; from those serving on national and international committees with her; and from friends who may have pertinent information. Full credit will be given for material used and any material submitted will be promptly copied and returned.

KODACHROME SLIDES

During last summer the Department of Education of the American Museum of Natural History, New York City, made available to schools and colleges their first series of kodachrome lantern slides. This set of twenty-five slides on "The Evolution of the Horse," two by two-inch size and bound in glass sells for $15.00. This set was tested with high-school teachers to insure the best selection of content from the teacher's viewpoint.

Realizing that many teachers are interested in this new visual aid, we quote further information regarding the slides furnished us by Grace F. Ramsey, Associate Curator of the Department of Education of the Museum.

Walter Granger, famous palaeontologist at the American Museum, has endorsed the accuracy and fidelity of the slides which are reproductions of exhibits in the museum.

A process of duplicating Kodachrome pictures has been developed by the museum so that careful control of the color of the final slide is maintained. The original photographs of the exhibits are made on the larger Kodachrome sizes so as to retain as much detail as possible. These large pictures are then rephotographed down to the thirty-five millimeter size using an artificial light source accurately adjusted as to color temperature. A complete series of faint complementary color correction filters makes it possible to adjust the hues of the final slides to as close a duplicate of the original colors in the museum exhibit as is necessary to maintain fidelity.

The "Evolution of the Horse" series contains maps of the chief fossil deposits in the United States, pictures of the formations in which the fossils are found, a progressive series of the fossil horse skeletons, Charles R. Knight's famous paintings of restorations of the fossil horses, and the contemporary life of each period. Slides comparing the skulls, hooves, and overall size of the earliest and modern horses complete this unusual series. A special manuscript has been written describing the slides and the story of "The Evolution of the Horse."

This set of slides is the first of several series which have been planned. The Story of the Dinosaur and Ancient Man will follow soon. The "Evolution of the Horse" is already in use in the high schools of New York City.

BOOKS ON SCIENCE AND TECHNOLOGY

The statistical story of publication in the United States of books on these subjects has been revealed by various censuses. Frank R. Wilson, Chief of the Division of Public Relations of the Bureau of Census, sends us this story which our readers will enjoy—for the sake of information!

The publication of books on science and technology has shown a steady increase in the United States for the last decade according to statistics compiled by the Bureau of the Census.

The year 1939 thus far marks the peak of production for publishers of books on scientific and technological subjects with a total of 3,432,642 volumes. Figures for that year are the latest available, since the Census of Manufactures, covering production in all American industries, is taken only biennially. The next Census, to be conducted in 1942, will cover 1941 production.

The 1939 total represents an increase of more than a million volumes over the 1937 total of books on science and technology, 2,380,351 volumes.

Separate statistics on production of books on

science and technology have been compiled by the Census Bureau biennially since 1925. They are:

1935	1,937,084
1933	1,611,642
1931	1,818,585
1929	2,294,660
1927	2,392,044
1925	2,094,343

The Bible, however, is still America's best seller, as is indicated by the number of Biblical volumes published. Figures covering 1939, show the annual output of Bibles, Testaments, and parts of the Bible published in separate covers, to be 7,927,848 volumes, compared with 5,579,317 in 1937. Both 1937 and 1939 recorded tremendous increases in total number of Bibles printed. For earlier census years Bibles published were: 1935—591,173; 1933—666,448; and 1931—1,376,680.

The number of complete Bibles published in 1939 was 2,348,069. Testaments published separately numbered 1,268,614. Parts of the Bible (not whole Testaments) numbered 3,361,234 volumes, while an additional 969,931 Biblical volumes were not classified by text.

While the production of Bibles showed an immense increase, the publication of fiction recorded a heavy decline, 13,511,181 volumes in 1939, compared with 25,454,135 volumes in 1937.

The total number of all books published in 1939 was 180,142,492 volumes, compared with 197,359,076 volumes in 1937; 140,651,953 volumes in 1935; 110,789,913 volumes in 1933; 154,461,622 volumes in 1931; and 214,334,423 volumes in 1929.

The largest single grouping reported was that of textbooks for school use, not distributed as to subject matter, which amounted to 63,274,758 volumes in 1939, compared with 72,771,685 volumes in 1937.

Next high in 1939 in total numbers were books for juvenile readers, 34,848,416 volumes, compared with 29,336,530 volumes in 1937.

Statistics on other books, by class and number, for 1939 and 1937, are:

Agriculture and related subjects	1,018,809	1,034,607
Biography	2,384,647	2,754,390
Fine arts	590,885	694,163
History	2,306,829	1,238,806
Law	2,356,395	2,448,165
Medicine	1,868,892	3,923,532
Music (musical notations)	5,682,042	6,722,598
Poetry and drama	1,499,477	1,788,541
Religion and philosophy	6,413,606	6,944,102
Sociology and economics	886,751	1,156,885
Travel and geography	1,482,138	1,641,931
Reference	6,716,403	3,841,442
Miscellaneous	16,196,422	23,367,371
Bluebooks, directories, catalogs, etc.	7,724,351	4,280,525

Publication of pamphlets more than doubled in number, with a 1939 total of 540,536,202, compared with 216,847,761 in 1937.

Maps, atlases, and globe covers published in 1939 numbered 64,309,275 compared with 103,867,467 in 1937.

TEACHER EDUCATION

The education of teachers for present-day professional service provides challenging problems for higher education. Many new programs are under way throughout the country. None is more interesting, perhaps, than the all-university program at Syracuse University. The report on this plan is published by the American Council on Education under the title, *A Functional Program of Teacher Education, as Developed at Syracuse University*. We quote from an abstract furnished by the Council:

> Are general and professional education correlative aspects of one and the same process of preparing the student for the teaching profession, or are they two quite distinct areas of competence? What experiences are most likely to be valuable to prospective teachers in helping them to understand girls and boy? to know and make intelligent use of the community and its resources? to get the feel of classroom procedure and appreciate the great variety of problems with which they are soon to be confronted on the job?
>
> These and related questions are discussed in stimulating fashion by the several members of the all-university School of Education at Syracuse University. In the first two chapters, Harry S. Ganders traces the historical development and describes the present organization of the all-university program. The curious system of "dual" professorships and registration, according to which professors hold rank and students are formally enrolled in the School of Education and one other university school of their choice, receives attention in Chapter III by Roy A. Price.
>
> The selection of students is next taken up by Maurice E. Troyer, with considerable attention to the criteria of selection, the methods of the committee on "dual" enrollment, and the continuous nature of selection and guidance at Syracuse. Ralph E. Strebel then goes into the contributions of the institutional teacher placement bureau. One of the important features of this whole setup is the close integration of all its constituent parts. Basic to the policies governing placement, for instance, is the principle that the bureau's area of influence and responsibility should cut across the entire program.
>
> The methods and objectives governing the professional curriculum are next presented by

Helene W. Hartley. One of the striking features of this curriculum is the emphasis on direct contact with adolescence by having students take over club leadership in some organization in the city that specializes in leisure time activities for young people. This arrangement is described by Russell T. Gregg and Maurice E. Troyer. The approach to the public school curriculum is likewise at first hand. The next three chapters, by Helene W. Hartley, Maurice E. Troyer, Ralph E. Strebel and Russell T. Gregg, describe the interplay between seminar work and practical experience as student teachers, both in the schools of Syracuse and in smaller schools within a radius of about 100 miles of the city.

An example of the way "dual" enrollment works out is described by J. Wallace Page in the field of science education. In the final two chapters Helene W. Hartley considers the teacher's responsibilities in education and to the profession, and the next steps for Syracuse. The book is profusely illustrated with forms and syllabi of various kinds while perhaps a fifth of the volume consists of appendices likewise given to analytical materials and checklists used in connection with the program.

PUBLICATIONS ON YOUTH PROBLEMS

Several summary reports of extensive surveys in the field of youth problems, including results of experimental programs, demonstrations, and elaborate investigations are now being prepared for the American Youth Commission of the American Council on Education. The following resume, which also lists reports recently published, has been prepared to bring us up to date on the activities of the Commission.

The needs of youth in the post-emergency world are outlined in the general report of the American Youth Commission of the American Council on Education now in preparation. Tentatively titled *Youth and the Future,* the report is based on six years of study of problems incident to the care and education of the 22,000,000 American youth by the fifteen-member Commission which is composed of leaders in the educational, business, and labor worlds.

The general report climaxes a series of publications containing results of investigation in the general problem areas of education, employment, occupational adjustment, vocational guidance, recreation, health; and such specialized areas as rural youth and youth of minority status groups.

Formation of community recreation authorities, composed of representatives from the schools, the public libraries, the municipal recreation boards, and other groups interested in leisure time use is advocated in *Time on Their Hands: A Study in Leisure, Recreation, and Young People* by C. Gilbert Wrenn, professor of educational psychology at the University of Minnesota, and D. L. Harley, Commission staff member.

Work Camps for College Students describes the activities in five camps sponsored by the American Friends Committee. Written by Kenneth Holland, associate director of the Commission in charge of the work camps study, it continues the story of privately operated work camps begun with *Work Camps for High School Youth.*

The six books which resulted from the Negro Youth Survey are being interpreted in a volume of findings and conclusions entitled *Color, Class, and Personality* by Robert L. Sutherland, associate director of the Commission for studies of Negro youth. A recent addition to this series was *Thus Be Their Destiny,* which describes interviews with several hundred Negro youth in Milton, Pennsylvania; Greensboro, North Carolina; and Galesburg, Illinois.

A significant study of the national aspects of unemployment of youth is being prepared under the direction of Paul T. David, associate director of the Commission for Research. It is tentatively titled *Youth Employment and Unemployment.*

Publications during the last summer were:

Wrenn, C. Gilbert, and Harley, D. L. *Time on Their Hands: A Study of Leisure, Recreation, and Young People.* Washington, D. C.: American Council on Education, 744 Jackson Place, 1941. Cloth, illustrated, 266 pp. $2.00.

Holland, Kenneth. *Work Camps for College Students.* Washington, D. C.: American Council on Education, 744 Jackson Place, 1941. Paper, illustrated, 27 pp. 25¢.

Atwood, J. Howell; Wyatt, Donald W.; Davis, Vincent J.; Walker, Ira D. *Thus Be Their Destiny: The Personality Development of Negro Youth in Three Communities.* Washington, D. C.: American Council on Education, 744 Jackson Place, 1941. Paper, 96 pp. 75¢.

Abstracts

SCIENCE

BAILEY, HILLARY G. "Points from a Retouching Pencil." *Camera Craft* 47:344–346; July, 1940.

Better techniques in using retouching pencils are described in this article.

—C.M.P.

ANONYMOUS. "New Fabrics Defy Wrinkles, Damp, and Even Germs." *Science News Letter* 37:12; July 6, 1940.

Crease-resistant sport cottons, ginghams, and lawns are now available as well as the more familiar voiles that defy wrinkling. The crease-resisting process is described as beyond doubt the outstanding development in fabric finishing since mercerizing was discovered a good many years back.

—C.M.P.

HEXTER, PAUL LOUIS. "The Function of Photography." *Camera Craft* 47:221–230; May, 1940.

The primary purpose of photography is to increase knowledge in a particular field. It is an additional form of vision, greatly supplementing our normal vision. Several photographs are used to emphasize this major thesis.

—C.M.P.

DAVIDSON, M. "The Origin of the Moon." *Discovery* 2:639–641; December, 1939.

Sir George Darwin's theory that the moon once formed part of the earth and was separated from it still has acceptors, but in recent years the theory has been seriously questioned. Some of the objections to this theory as well as to the tidal theory of planet formation are enumerated in this article.

—C.M.P.

MORTENSEN, WILLIAM. "Seven Deadly Errors." *Camera Craft* 47:3–13; January, 1940.

Seven deadly errors that conspire to spoil the work of outdoor portraits involve the use of backgrounds: (1) the confused background, (2) the contrasty background, (3) the background badly out of focus, (4) "traps" in the background, (5) the background of wrong emphasis, (6) the background that dwarfs the subject, and (7) the background wrongly placed in relation to head or picture space. Illustrated.

—C.M.P.

GRIERSON, SAMUEL. "Keep It Clean." *American Photography* 34:42–45; January, 1940.

The author emphasizes the great need for absolute cleanliness in photography—a clean camera, a clean dark room, and clean apparatus, and solutions.

—C.M.P.

KELLOGG, REMINGTON. "Whales, Giants of the Sea." *The National Geographic Magazine* 77:35–90; January, 1940.

Whales are the largest creatures of all time, show tender affection for their young, but can maim or swallow human hunters. There are 25 illustrations and specific descriptions. There is also 31 paintings of whales, porpoises, and dolphins by Else Bostelmann.

—C.M.P.

HILDEBRAND, J. R. "Our Most Versatile Vegetable Product." *The National Geographic Magazine* 77:143–200; February, 1940.

This splendid article traces the intensely interesting story of rubber from its origin in millions of tropical trees to its final transformation by the chemist into thousands of articles, from tires to teething rings. Rubber is one of the two very vital raw materials necessary in war that the United States does not produce. There are 51 illustrations and 21 natural color photographs by Culver and Roberts.

—C.M.P.

O'REILLY, JOHN. "South Florida's Amazing Everglades." *The National Geographic Magazine* 77:115–142; January, 1940.

This seldom-visited area is a nature lover's paradise. Teeming with rare birds and wild life is the Big Cypress Swamp. There are 26 pictures and a map.

—C.M.P.

VALENTINE, PHILIP C. "The Business of Buying a Camera." *American Photography* 34:96–104; February, 1940.

Practical advice for all prospective camera buyers is contained in this article. The author says it is sheer nonsense to start with a cheap camera and "work up" when you can start with a better one. Buy the best camera you can afford.

—C.M.P.

PELS, HERBERT. "What Makes a Picture?" *American Photography* 36:79–88; February, 1940.

The true measure of a picture is to be found in the degree in which it approaches its function, which is to universalize its subject, or some characteristic of it. Technical aspects, composition, and so on are secondary considerations.

—C.M.P.

WOLD, PETER I. "The Mystery of Gravity." *Science Digest* 7:70–72; February, 1940.

Although Newton held that gravity is a property of matter and later Einstein formulated the hypothesis that gravity is a property of space, the fact is that with all our accumulated knowledge of science and with all of our improved techniques of measurement, we do not know what gravitation is. We can work with it, measure it in many places, use it, but we do not know what it is.

—C.M.P.

BENEDICT, H. C. "Filters Made Easy." *Camera Craft* 47:130–137, 108–191; March and April, 1940.

This article explains the reasons for using filters and when to use them.

—C.M.P.

MURPHY, ROBERT CUSHMAN. "Conservation's Silver Lining." *Natural History* 46:294–303; December, 1940.

This is a delightful story of the millions of guanays or Peruvian cormorants who inhabit the desert coast of Chile and Peru, whose diet consists of fish and who are responsible for the guano or nitrate beds. Many excellent photographs supplement the article.

—C.M.P.

CHANEY, RALPH W. "Bearing of Forests on the Theory of Continental Drift." *The Scientific Monthly* 51:489–499; December, 1940.

The distribution of plants in past geological periods has long been a perplexing scientific problem. How account for remains of tropical and subtropical plants at distances much farther north than they now exist? Did the plants or continents move? Wegener adduces the theory that the continents have moved. In this article, Dr. Chaney offers seemingly excellent proof that the continents have been stable for a relatively long period of time, and that forests have migrated southward in response to changing climate.

—C.M.P.

GILLIARD, E. THOMAS. "Unchallenged Champion." *Natural History* 46:258–273; December, 1940.

As exciting a story of adventure as modern exploration can tell led up to the discovery of this eighth wonder of the world and to its pronouncement, here for the first time in the English language, as the highest waterfall in the world. In a Venezuelan Lost World in the Guiana Highlands, an aviator named Jimmy Angel, while hunting a mountain of gold, discovered the world's highest waterfall. The discovery made in 1937 has since been confirmed by other explorations. Angel Falls, as it is now called, is at least 20 times as high as Niagara and it may be 30 times as high. Angel Falls seemingly dwarfs all other falls into comparative insignificance. It is at least 3500 feet high and it may be as much as 5000 feet. There is an excellent chart, pages *272–273*, showing the comparative heights and giving the locations of the 78 highest falls in the world. The second highest falls is Kukenaam Falls (2000 feet), also in Venezuela. Niagara Falls ranks 67 in height among the world's known waterfalls.

—C.M.P.

FURNAS, C. C. "Chemicals from the Farm." *Science Digest* 9:15–24; February, 1941.

This article is condensed from *The American Scholar*. The first part of the article discussed the production of alcohol from corn and molasses in the plants at Terre Haute, Indiana, and Peoria, Illinois. Wood, corn stalks and straw are possible sources of paper. Rayon could be made from corn stalks. Farm products offer a possibly rich future source of many valuable chemical products.

—C.M.P.

BARTON, WILLIAM H., JR. "An Astronomer Considers the Poles." *Science Digest* 9:39–42; January, 1941.

This article is condensed from the November issue of *The Sky*. It is correct to say down to the North Pole, and incorrect to say up at the North Pole. South is the only direction at the North Pole and the seasons are sunrise, summer or daytime, sunset, and winter or night. The sun remains above the horizon 186 days at the North Pole (March 21 to September 23), below the horizon for 179 days. Twilight lasts for seven weeks (September 24 to November 14) and dawn from January 29 to March 20. The one long night is 76 days long.

—C.M.P.

ANONYMOUS. "Why No Gas Warfare?" *Science Digest* 9:75–76; January, 1941.

Poison gas used so extensively in the first World War (in November, 1918, half of the German and one-fourth of the British ammunition expenditures were gas shells—27 per cent of American casualties were caused by gas) has not been used during the present conflict. Why not? Possible reasons: fear of public opinion of retaliation, or of the effect of large-scale civilian casualties. Perhaps gas has not been needed or is held as a final reserve. Yet its use in the future need not cause any surprise.

—C.M.P.

SNYDER, LAURENCE H. "The Study of Human Heredity." *The Scientific Monthly* 51:536–641; December, 1940.

This is the first of a series of eight articles on different aspects of heredity by different authors. Dr. Snyder lists seven practical applications of heredity, five fundamental conclusions regarding

practical problems in human beings, and six principles involved in the analysis of human pedigrees.

—C.M.P.

ANONYMOUS. "Science Review of the Year." *Science News Letter* 38: 387–400; December 21, 1940.

This is the annual summarization of the major science events of the year. Among the great events are: the electron microscope which opens up a new world, brightest comet since 1910, and vaccines for influenza and measles.

—C.M.P.

SHREVE, R. NORRIS. "Precious and Semi-Precious Jewels—Their Chemical and Beautifying Qualities." *Science* 92: 566–570; December, 20, 1940.

Attributes making gems precious include: (1) beauty of color, (2) beauty of structure, (3) beauty of luster, (4) beauty due to transparency, (6) durability or hardness, and (7) rarity.

—C.M.P.

BARRETT, NESTOR AND WYCKOFF. "Darkroom Sinks and Drainage." *Camera Craft* 47: 593–600; December, 1940.

This illustrated article discusses the most desirable types of darkroom sinks and drainage systems, where to locate them, and how to best utilize them.

—C.M.P.

AGNEW, P. G. "The Human Side of Numbers." *Science Digest* 8: 45–48; December, 1940.

Most people prefer certain numbers ending in 0 or 5 and even numbers are preferred, as also are small numbers. Merchants usually list articles selling by the dozen or by the pound as so many odd number cents, also as a cent or a few cents under the nearest dollar value.

—C.M.P.

EGLOFF, GUSTAV. "Petroleum and National Defense." *Science* 92: 520–522; December 6, 1940.

The United States produces 61 per cent of the world's petroleum, and the Americas produce one and a half billion barrels out of the two billion yearly production of the whole world. The United States produces practically all of the world's production of 100 and higher octane aviation gasoline. Such gasoline gives the airplane better maneuverability, speed of climb, shortness of take-off, and dead weight lifting power. Germany has about two and one-half per cent of the world's crude oil, controls another three per cent in captured countries. Russia's production is about 10 per cent, Italy one-tenth of one per cent, Japan about the same, the Dutch East Indies three and a half per cent, and England has accessible about 15 per cent as long as her maritime power endures.

—C.M.P.

HOFSINDE, ROBERT. "Talk—Without Talk." *Natural History* 47: 32–39; January, 1941.

The American Indian's greatest invention was the sign language. The Indians had the most marvelous gesture-development found in any continent, a method of communication comparable to the invention of the Chinese ideographs of the Orient. The American Indian sign language attained a vocabulary and complexity from 20 to 100 times as great as any other comparable system elsewhere in the primitive world. At present there are few Indians left who can talk sign language fluently. There are five pages of photographs showing how the sign language is "spoken."

—C.M.P.

WATTS, W. A. "Flame-Feathered Flamingos of Florida." *The National Geographic Magazine* 79: 56–65; January, 1941.

This article describes the Flamingo colony at Hialeah Park, near Miami, Florida. There are nine natural-color photographs of these beautiful birds.

—C.M.P.

PALMER, WILLIAM A. "It's All Done with Mirrors." *Camera Craft* 48: 36–40; January, 1941.

This illustrated article explains how Hollywood achieves some of its trick effects in photography.

—C.M.P.

BRAGG, SIR WILLIAM. "Science and the Nation." *Science* 93: 25–27; January 10, 1941.

This is the address of the president of the Royal Society. He points with pride to the past accomplishments of members who have recently died but believes present accomplishments are as truly great. Science has become an integral part of the educational system, yet the changes actually made are ridiculously small. However, he feels that science is now making great contributions to the nation's security and well-being.

—C.M.P.

BRADLEY, JOC. "Color Simplified." *Camera Craft* 48: 59–65; February, 1941.

This article discusses the steps necessary to make successful color photographs. Color photography, still in its infancy, offers many difficulties both to the professional and to the amateur.

—C.M.P.

COLBERT, EDWIN H. "Where the Cats Came From." *Natural History* 46: 288–289; December, 1940.

This is the diagrammatic story of the origin of cats. The first cats appeared with the advent of the oligocene period about 35 million years ago. They were descendents from civet-like ancestors of the Upper Eocene age (55 million years ago). Our domestic house cats were de-

rived from the small Old World Cats of the Felis group.

—C.M.P.

ANDREWS, ROY CHAPMAN. "Lord Jitters." *Natural History* 46: 290–292; December, 1940.

All lovers of animals, especially cats, will thoroughly enjoy this story of a deaf, white Persian cat whom the author admits is the autocrat of the Andrews family.

—C.M.P.

ANTHONY, HAROLD E. "The Dog and the Rabbit." *Natural History* 46: 293; December, 1940.

Here is a fine animal story of a rabbit and a dog that left the dog in a most puzzled state of mind.

—C.M.P.

ANONYMOUS. "Camouflage Trickery." *Popular Science Monthly* 138: 60–62; February, 1941.

This is an illustrated article on that important aspect of war-camouflage.

—C.M.P.

VAN DUYNE, SCHUYLER. "Streamlined Gasoline Promises More Miles a Gallon." *Popular Science Monthly* 138: 122–125, 235; February, 1941.

From present indications, 1946 cars will drive faster and probably get twice as many miles per gallon of gasoline as compared to 1941 cars. The petroleum industry has three times as much oil on tap is it thought it had in 1917, and from each barrel it extracts twice as much gasoline as it did 20 years ago. Car engines of the same power average only half the weight they did 15 years ago and almost 90 per cent more power is produced for the same amount of fuel used.

—C.M.P.

ANDREWS, BERT. "Taste Engineers." *Popular Science Monthly* 138: 64–67; March, 1941.

This article describes the work of an unusual occupation—professional tasters. However, these professional tasters often depend as much or more on smell as they do taste. Taste and smell are often more accurate than chemical tests.

—C.M.P.

TEALE, EDWIN. "How Bats 'See' in the Dark." *Popular Science Monthly.* 138: 102–104; March, 1941.

After 10,000 experiments in a Harvard laboratory, two scientists have solved a problem that has baffled men for over 150 years—accurate night flying by bats. They conclusively proved that they fly by sound rather than by sight, giving off sounds in flight at the rate of 30 cries a second with a vibration frequency of 30,000 to 70,000 vibrations a second. Human ears have a top limit of about 20,000 vibrations. As flying bats approached an obstacle the number of cries increased to 50 a second.

—C.M.P.

DEASY, GEORGE F. "Geography of the United States Soybean-Oil Industry." *The Journal of Geography* 40: 1–7; January, 1941.

No plant in American history has had the increase in acreage devoted to it as has the soybean. In usage it is one of the most versatile of plants. It can be grown wherever corn can. In 1938 the United States had 7,789,000 acreas devoted to soybeans of which 2,898,000 acres were harvested for beans, the yield of the latter being 57,665,000 bushels. Illinois is the great soybean state, followed by Indiana, Iowa, and Ohio.

—C.M.P.

ANONYMOUS. "$1,000 A. A. A. S. Prize Given for Plant Research." *Science News Letter* 39: 19; January 11, 1941.

Professor D. R. Hoagland and Dr. D. I. Arnon of the University of California received the annual $1,000 prize of the American Association for the Advancement of Science for research that upsets the classic theory of plants' absorptions of minerals. Roots were heretofore thought passive, but these investigators in a series of experiments, prove that plant roots actively seek nutrients.

—C.M.P.

Book Reviews

REFERENCE BOOKS

SMITH, KENNETH M. *The Virus, Life's Enemy.* New York: The Macmillan Company, 1940. 176 p. $2.00.

The frontier of the modern fight against diseases is to be found in the laboratories of the scientists who are studying the behavior of the viruses. Smallpox, poliomyletis, encephalitis, measles, mumps, epidemic influenza, and the common cold are some of the common ailments of human beings caused by viruses. Others attack animals, insects, plants, and even the bacteria.

The scientist is not sure whether or not a virus is just a chemical substance or an exceedingly minute living organism, smaller than most of the known disease producing bacteria.

The present volume by a noted British author will enable the lay reader to get a much clearer conception of the nature of viruses and of the methods of investigation used in their study.

The book is recommended for lay readers, as an important addition to the biological library of the high school, to the high school science teacher, and as supplementary reading for high school classes in general biology.

—R.K.W.

JAUNCEY, G. E. M., AND LANGSDORF, A. S. *M.K.S. Units and Dimensions.* New York: The Macmillan Company, 1940. 69 p. $1.00.

This is a short but detailed exposition of the Meter-Kilogram-Second (mks) system of fundamental units adopted by the International Electrotechnical Commission (ICE) in June, 1935. Arguments for the adoption of the *ohm*, maintained as a protype (discarded by the International Committee of Weights and Measures), as a fourth basic unit are presented. The authors, using accepted definitions of quantities, describe a sequence of experiments whereby all units used in electricity and magnetism may be determined in terms of the three fundamental units and the ohm (mkos). The procedure suggested is novel and of some interest.

—Herman Roth.

JAMES, HARLEAN. *Romance of the National Parks.* New York: The Macmillan Company, 1939. 240 p. $3.00.

The United States has more than 7,000,000 acres in its National Parks scattered from Maine to California, Florida to Minnesota, and also in Alaska and Hawaii. This book pictures some of the grandeur and vastness of our parks and the inspiration their beauty creates. But no book can describe, nor photographs picture, the feelings and emotions one has as he visits some of these mighty wonders of nature. They are indeed one of our richest, most prized possessions.

Miss James describes some of the history, and journeys into each of the Parks. The book is illustrated with 123 photographs, many of them familiar to everyone. They call up many pleasant memories to those who have been there personally, and to others they act as inspiration in a resolution to visit them sometime soon.

This is an excellent supplement to United States Geography and for use in Conservation units.

—C.M.P.

BOOS, WILLIAM F. *The Poison Trail.* Boston: Hale, Cuchman and Flint, 1940. 380 p. $3.00.

In this unique book one of America's best known toxicologists relates his experiences and studies in the field of poisonous substances. He draws fully from his own experiences as physician, as consultant in the use of poison for industrial purposes, as in food investigations, and in the field of lego-toxicology where he has appeared as an expert witness in many of the famous civil and criminal cases of the last twenty years. His lifetime of activity in his chosen field has included a variety of experiences that rarely come to one man. He has fascinating anecdotes and case histories to illustrate the use and misuse of a large number of poisons. Many accepted beliefs are exploded. The appendix gives the procedures used by Dr. Boos in analyzing and determining the presence of poisons.

Dr. Boos maintains that there is no such thing as ptomaine poisoning, that no antidote is known for any given poison, that the ill-effects of all bacterial diseases result from poisons, that the quickest-acting poison is a cyanide, but that arsenic is the murderer's "poison of choice" for a variety of reasons, that alcohol and tobacco are poisons in the true sense of the term. Altogether this is a most enjoyable and readable book.

—C.M.P.

EASTMAN, FRED. *Men of Power.* Nashville: Cokesbury Press, 1940. 224 p. $1.50.

This is the fifth and concluding volume in a series on the lives of great men. The first five volumes are fascinating reading, with plenty of human interest. They give the heredity, cultural and national background, friendships, habits of work, and philosophies of the men considered. The present volume includes Lenin, Gandhi, Stevenson, and the scientist, Trudeau, who revo-

lutionized the treatment of tuberculosis. Scientists treated in preceding volumes are: Pasteur, Leonardo da Vinci, Darwin, Franklin, and Burroughs.

—G.M.P.

ANONYMOUS. *461 Timely Pictographs.* Washington: Science Service (Science News Letter).

Pictographs are statistics in picture form. This scientific method of presenting complex data in simple, understandable form was brought to America in 1932 from Austria. Pictographs are self-explanatory, utilize a variety of symbols, chart only comparisons, and compare approximate quantities, not exact figures. Readers of *Science News Letter* are well acquainted with pictographs or telefacts.

The present collection of 461 pictographs are classified both alphabetically and by subject. Science teachers will find many telefacts of great significance in their science teaching.

—C.M.P.

SOLOMON, ARTHUR K. *Why Smash Atoms?* Cambridge: Harvard University Press, 1940. 174 p. $2.50.

The science teacher who has not followed closely the recent advances in our knowledge of the atom will find in this book just what he wants to know. There are three parts: I. What Is the Atom? II. How Smash the Atom? III. Why Smash the Atom? It is a popular science treatment for the lay reader and will be more helpful for elementary class use than a more technical discussion. You will find interesting illustrations. One of the chapters takes up the possibilities of increasingly valuable applications in medicine.

—W.G.W.

SCHEINFELD, AMRAM. *You and Heredity.* New York: Frederick A. Stokes Company, 1939. 434 p. $3.00.

This is undoubtedly the best treatise on human heredity that has been made available for the general reader. The author has done a splendid job of popularization in a field of intriguing interest, but in which all previous attempts have lacked just a "little something." Probably the one thing that makes this book unusually appealing is the vast number of everyday, concrete examples. Specific questions are answered unequivocally in simple, easily understood terms. There are seventy-five excellent illustrations. Thus the book is not only the best book for the layman on heredity, but also for most science teachers whether elementary science, junior high school, secondary schools, or biological science survey course—as well as high school biology students and students in biological science survey. *Heredity and You* may be classed as one of the most outstanding books in recent years.

—C.M.P.

CURIE, EVE. Translated by Vincent Sheean. *Madame Curie.* New York: Garden City Publishing Company, Inc., 1940. 412 p. $1.49.

The story of the devotion of the discoverer of radium to her family and to science under trying circumstances is fascinating beyond the power of words to tell. Written by Madame Curie's youngest daughter, it gives the details of her life history: her childhood, her studies, what led to the years of drudgery trying to get radium enough to prove its existence, and how she disliked public honors. The story includes that of her husband, Pierre Curie who became obsessed with the desire to cooperate in the tedious work of experimenting and testing. This book is a 1940 reprint of the original book of three years ago which sold then for $3.50. "Inspiring and deeply moving, written with sincerity and distinction, *Madame Curie* is a true classic of biography."

—W.G.W.

FRANCK, HARRY A. *The Lure of Alaska.* New York: Frederick A. Stokes Company, 1939. 306 p. $3.50.

The Lure of Alaska is a most interesting, enjoyable book. Interspersed with facts as well as entertainment this is a most informing book. The book is written in Franck's usual vivid, revealing style. Franck pictures Alaska not as a bleak, dreary land, but as a land covered (in summer) with flowers, snowpeaks and glaciers. The love of the Alaskans for their home and their disdain of the Outside is impressed upon one.

Upon reading this book one feels as if he really knows Alaska. It is almost uncanny how Franck learns so much as he goes about on his travels and then is able to put this information down later in such an entertaining way. He is a keen observer and his numerous books on his journeys into strange lands are all fine. This is one of his best narratives.

The book comprises an interesting supplementary reader in geography and a valuable guidebook for the visitor to this land of the North.

—C.M.P.

QUINN, VERNON. *Shrubs in the Garden and Their Legends.* New York: Frederick A. Stokes Company, 1940. 308 p. $2.50.

This is another of those delightful books by Quinn on legends about plants. Previous titles have been: *Seeds, Their Place in Life and Legend; Roots, Their Place in Life and Legend;* and, *Stories and Legends of Garden Flowers.*

In this book the author gives many essential horticultural facts and salient information of practical use. Species and varieties of the most popular shrubs are described. Interesting stories are related about many of the shrubs. And many of them have a most interesting ancestral family history! A few of the shrubs described include: Azalea, barberry, burning bush, but-

terfly bush, dogwood, flowering-crab, forsythia, gala-bush, japonica, lilac, mock-orange, privet, Rose-of-Sharon, snowball, spirea, and weigela.

This is a delightful supplementary book for the high school biology class.

—C.M.P.

TAYLOR, F. SHERWOOD. *Science Front, 1939.* New York: The Macmillan Company, 1939. 301 p. $2.50.

The recent discoveries in the science field are reviewed and discussed by this English author. Technical information is given about discoveries so that the lay reader can understand and appreciate them.

This interesting book gives accounts of discoveries and developments of such subjects as chemotherapy, sex and the steroids, war against cancer, the making of oil from coal, television, Helium II, atomic structure, polar aurora, the stuff of life, science and plant growth, the new quartz clock, and our view of the universe. Illustrations include many diagrams and several photographs.

—Roy V. Maneval.

FRAPIE, FRANK R., AND JORDAN, FRANKLIN I. (Editors). *The American Annual of Photography 1941.* Boston: American Photographic Publishing Company, 1940. 276 p. $2.25.

This is Volume Fifty-Five of the American Annual of Photography. It will appeal to the general reader as well as to the amateur and professional photographer. There are more than one hundred illustrations ninety-five of which are full page. These photographs, showing the trends in photography, have pertinent data as to kind of camera used, lens, time, developer, and so on.

One of the most important features of the Annual are the many splendid articles by outstanding men in photography. These include: (1) My Aims and Methods, by Julian Smith, (2) Using Polarized Light, by Calvin Rustrum, (3) Modern Trends in Pictorial Photography, by Paul L. Anderson, (4) Diversions of a Nature Photographer, by Linwood M. Chace, (5) Press Photography, by Stanley N. Tess, (6) Lines in Landscape, by H. W. Honess Lee, (7) The Paper Negative, by Adolf Fassbender, (8) The Photographic Darkroom, by Charles W. Seager, (9) Photoflash Photography, by Hy Schwartz, (10) Color Photography, by Joseph S. Friedman, and (11) A Perfect Print, by Eugene V. Connett.

—C.M.P.

WALL, E. J., AND JORDAN, FRANKLIN I. *Photographic Facts and Formulas.* Boston: American Photographic Publishing Company, 1940. 383 p. $2.50.

This is a revised and practically rewritten volume of two earlier editions. In the intervening years since the last edition, 1924, many new formulas and techniques have been developed. The old formulas that have proved their permanent worth have been retained. The book is an excellent working guide to practical photographers, giving plain working directions and formulas for the most commonly used photographic processes. There are 35 chapters, including such topics as exposure, developing, defects in negatives, toning, lantern slides, copying, color photography, and so on.

—C.M.P.

MEADE, RICHARD K. *Portland Cement.* New York: The Chemical Publishing Company, 1939. 707 p. $10.00.

This new edition of a well known book retains in essential form the subject matter of the previous editions, and covers the field of portland cement from theory to finished product. The chapters are grouped under the following headings: Introduction, Manufacture of Portland Cement, Analytical Methods, Physical Testing and Miscellaneous Data. By far the major portion of the volume is devoted to the manufacture of portland cement.

The introduction discussed the historical development of the industry and the nature of portland cement. Considerable emphasis is given to the research which has influenced the development of the cement industry.

The section devoted to the manufacture of cement begins with the raw materials, their properties and preparation, quarrying and mixing. The wet and dry processes are then described in detail. Equipment for quarrying, crushing, grinding and burning are described in detail. The theoretical and practical value such as machinery data, power and fuel requirements and cost data are included in this section.

Sections devoted to Analytical Methods, Physical Testing and Miscellaneous Data make up the rest of the book. These sections contain the standard methods of analysis and physical testing as developed by the organizations interested in standardization. Such material may be found in most handbooks.

Numerous illustrations and diagrams are used throughout the book to show equipment and data. No typographical errors are noted.

The book is not highly technical and anyone interested in portland cement should benefit from reading it.

—O. M. Smith.

NICOL, HUGH. *Plant Growth Substances.* New York: The Chemical Publishing Company, 1939. 106 p. $2.00.

This booklet of 108 pages deals with those growth producing substances that hasten the rooting of cuttings or produce living roots on stems and leaves of intact plants. It is divided into two parts. Two of the ten chapters are written for the lay reader, horticulturists, gar-

deners, and student, wherein are briefly given the discovery of a number of agents and chemicals used today with detailed directions for the purchase, preparation, and use of the two practical ones; indol-acetic acid and phenyl acetic acid. The remainder of the book constituting 85% is quite technical. The methods of preparation and synthesis, together with the biochemical properties are discussed for the auxin and indol and naphthalene compounds. There follows a chapter on the methods of application, the botanical tests to determine the effectiveness and comparative study. Some space is devoted to the agricultural researches having a possible bearing on growth-substances in soils, and manures with particular references to the constituents in urine and the occurrence of other bodies than the auxin.

Since extremely dilute concentrations of 1 part in 100 million parts of water are effective, a discussion of the effect of concentration and chemical constitution and phytological activity occupies a chapter. The book ends with descriptions of the chemical and biological methods of detecting, identifying, and measuring the effectiveness of the various substances.

Extensive lists of references follow most chapters, the index contains entries on about 100 compounds and about 167 authors.

—O. M. Smith.

SHINKLE, JOHN H. *Textile Testing.* New York: Chemical Publishing Company, Inc., 1940. 272 p. $3.00.

This is a most practical book on textile testing involving physical, chemical and microscopical testing. The book will serve as a textbook or as a handy reference. Detailed directions are given. Some of the tests include: microscopical identifications of fibers and starches, chemical identification tests, quantitative fiber tests, thread count, thread strength, thermal tests, moisture tests, porosity tests, and so on.

Chemistry teachers will find it an excellent reference for the textile unit.

—C.M.P.

WEINGART, GEORGE W. *Pyrotechny.* New York: Chemical Publishing Company, 1939. 178 p. $5.00.

This book presents a brief but complete record of the developments of pyrotechny up to the present time. It is a practical manual for the amateur and professional chemist and would be especially valuable to the high school chemistry teacher and science club sponsor. It is a summary of forty years experience and contains recipes and methods for making every known article of fireworks in small and large quantities. Many possibilities to enliven that science club program or science club assembly program—colored fires, lights, stars, flares, rockets, roman candles, water fireworks, and so on.

—C.M.P.

SCHUCHERT, CHARLES, AND LAVERNE, CLARA MAE. *O. C. Marsh, Pioneer in Palaeontology.* New Haven: Yale University Press, 1940. 541 p. $5.00.

Born in 1831 on his father's farm near Lockport, New York, Marsh early developed a strong antipathy to farm work, an equally strong liking for hunting and for the out-of-doors, and a passion for collecting minerals. Not until he was twenty years of age did he go to Phillips Andover Academy and it was a year later that he made up his mind to study in earnest to prepare for college. Then fortune smiled upon him. His mother's brother, George Peabody, born in Danvers, Massachusetts, then a wealthy banker of London, England, provided young Marsh with money to finish the academy, go through Yale, and study abroad for three years. He put up the money to pay Marsh's salary as professor of Palaeontology at Yale, to build the Peabody Museum to house his growing collections, to pay the expenses of his collecting imps, the salaries of his assistants, both fossil hunters and preparateurs. He did not provide the brains or the indomitable will that carried Marsh on his brilliant career.

The authors have written a charming biography. It is not so much the life of a man as it is a portrayal of the work of the pioneer palaeontologist. In spots, it has the excitement of a Western thriller. Again it sparkles with humor. Primarily, it relates Marsh's substantial accomplishments in his chosen field of vertebrate palaeontology, accomplishments the authors are very competent to evalue.

Marsh's collections were willed to Yale. They consist of hundreds of fossil horses, toothed birds, flying dragons, sea serpents, immense dinosaurs—type specimens of the hundreds of new species and genera which Marsh first described and named. The book lists 268 papers which Marsh published, some of them elaborate monographs.

Three-fifths of the book is narrative and will be read by the layman with pleasure. The rest is more technical but far from dull. The volume is a fine addition to the as yet scanty list of biographies of great American scientists. It is well illustrated.

—E.R.D.

DOOB, LEONARD W. *The Plans of Men.* New Haven: Yale University Press, 1940. 411 p. $3.00.

"It is proposed," in this book, "to consider the nature of the plans that have been, that will be, and that should be attempted in terms of what is known about man."

A plan is based on (1) a knowledge of the people who will be affected, (2) a knowledge of the physical and social environments confronting these people, and (3) a knowledge of a goal to be achieved.

It has been proposed by the eugenists to try to improve human stock by sterilizing such unfit as the feeble-minded and stimulating the reproduction of desirable types. But "it has been computed that if the proportion of feeble-minded in the present population is one per thousand, to decrease that proportion to one per ten thousand will require 68 generations, or two to three thousand years, if it is done merely by stopping the propagation of feeble-minded individuals." "We have not the faintest notion of how to breed leaders in art, in science, in politics, in economic organization, in religion, in education." So the present plans of the eugenists seem futile. If all the plans of men could be criticized with equal definiteness the book would be more satisfactory.

But there are no laws of human nature or principles of social behavior, so planning social activities seems useless since you can predict the outcome. Similarly, "history as a guide to future plans offers only very tentative hypotheses and hence cannot claim that a plan is doomed to success or failure because of some occurrence in the past." Individual planning seems equally hopeless for "the question of the freedom of the will is eventually raised and at that point all discussion must cease."

The author seems to favor regional planning as illustrated in the project of the Tennessee Valley Authority but even here he says, "Whether or not the swing to industrialism is good or bad for the inhabitants of the valley is a question that is seldom discussed by the officials of the Authority." In other words, no careful evaluation of the goal to be achieved has been attempted. It is merely assumed that it is good.

There are 164 items in the bibliography. The author seems to have amassed so large an amount of conflicting data on planning by humans that he himself is none too clear as to its significance. Part 4 is devoted to perplexing problems.

The book is stimulating reading. It raises many questions and settles few. Some pages smack so strongly of foreordination they would delight a Scotch Presbyterian.

—E.R.D.

Cutright, Paul Russel. *The Great Naturalists Explore South America.* New York: The Macmillan Company, 1940. 340 p. $3.50.

To most of us the animals of South America are even stranger than those of Africa or Asia. Only those of Australia seem more remote. The author of the present volume has done much to bring these animals of our neighboring continent into the realm of the familiar.

The book begins with a summary of the work of the great naturalists whose travels have taken them to South America. These include Alexander von Humbolt, Charles Waterton, Charles Darwin, Richard Schomburgk, Alfred Russel Wallace, Henry Walter Bates, W. H. Hudson, and William Beebe. These are arranged in chronological order and their more important publications critically reviewed. For the student there is also a considerable bibliography.

The major portion of the book consists of descriptions of South American animals, beginning with vampire bats and armadillos and ending with the great snakes, electric eels and butterflies. Each of the animal biographies is illustrated. The descriptive material is not that of the technical worker but is interspersed with interesting anecdote and colorful narrative drawn from the works of the naturalists.

The author is himself a trained zoologist. The reader may expect, therefore, authentic treatment of each subject.

The book will be a welcome addition to the libraries of all those truly interested in animal life. The book will strike the reading level of the better students in senior high school or those in junior college. Laymen with some training and scientific interest will find it both entertaining and profitable. Some will be inclined to skip the travels of the great naturalists to explore at once the mysteries of the unfamiliar animals.

—R.K.W.

Tweney, C. F., and Hughes, L. E. C. *Chambers's Technical Dictionary.* New York: The Macmillan Company, 1940. 957 p. $5.00.

The aim of this dictionary is to give definitions of terms that are of importance in pure and applied science, in all branches of engineering and construction, and in the larger manufacturing industries and skilled trades. It is a dictionary of technical terms, written by specialists, partly for other specialists, but more specifically for the technically minded man-in-the-street. All science teachers, textbook writers, and writers of articles on science, will find the book both practical and comprehensive.

—C.M.P.

Hohman, Leslie B. *As the Twig Is Bent.* New York: The Macmillan Company, 1940. 291 p. $2.50.

This is one of the finest, most practical books on the training of children that the reviewer has happened across. While seemingly more addressed to parents than teachers, the latter can read it to their own advantage. Theoretical psychology relating to the training of children, especially in the home, is here made specific, concrete, practical. The book seems to be sound psychologically, assuming neither a radically progressive attitude, nor is it extremely conservative.

The book is most readable, almost in the nature of popular psychology, illuminated with many interesting case histories. The reviewer recommends it as excellent reading for teachers and for parents.

—C.M.P.

JONES, H. SPENCER. *Life on Other Worlds.* New York: The Macmillan Company, 1940. 299 p. $3.00.

Is life unique to this planet we call the Earth? What are the possibilities of life on other planets of the solar system, or on planets outside the solar system? *Life on Other Worlds* is an attempt to answer these questions as definitely as possible, taking into consideration all facts now known. In answering these questions, the author discusses the conditions necessary for life, the origin of the solar system, the possibilities of similar solar systems, and the physical conditions of all members of the solar system. Physical conditions include such things as desirable temperature, certain constituents in the atmosphere, atmospheric pressure and so on. Definitely life cannot exist on Mercury and the Moon because of the lack of an atmosphere, nor on Jupiter, Saturn, Neptune, and Uranus because they are too cold, have too dense an atmosphere, and undesirable atmospheric constituents. Conditions on Venus are most favorable, the planet Venus being more in the condition under which life may develop. On the other Mars is more nearly in the condition of a planet that may have once had life, as there is rather conclusive proof of a present low-order vegetative life. Other solar systems must be extremely rare, and then the conditions would have to be just right for life. The author comes to the conclusion that a planet about the size of the earth is the only possibility for life whether in this solar system or some other. Smaller planets would have little or no atmosphere and larger planets such as Jupiter and Saturn would have too dense atmospheres, made of such gases as marsh gas and ammonia.

This is an excellent book for popular reading by laymen, as supplementary reading in physical science survey courses, and for any teacher of science—elementary, junior high, high school or college. The author is Astronomer Royal and author of *Worlds Without End.*

—C.M.P.

ADAMS, MILDRED. *Getting and Spending, The A B C of Economics.* New York: The Macmillan Company, 1939. 126 p. $0.60.

For the general reader who is wholly confused by the shifting sands of modern economics, this small volume may serve as a useful primer. In many respects the author writes down to the reader so that the intelligent layman may be irked by the style. In general, the book tends to debunk the economists. Interpretations are clear but ultra-simple for the complex situations which they attempt to analyze. Questions are raised but there are no recommended solutions.

The book is recommended to the lay reader making a beginning in his reading program in the field of economics and so-called consumer education rather than to pupils in secondary schools or colleges.

—R.K.W.

BOAS, FRANZ. *Race, Language and Culture.* New York: The Macmillan Company, 1940. 647 p. $5.00.

The volume consists of a selected lot of reprinted articles originally appearing in a variety of magazines during the past fifty years. Those dealing with race are mostly concerned with physical changes of European peoples after immigration to the United States and with the growth of their children. The language studies deal with some Indian languages. The culture articles treat a variety of phases of the cultures of Indians, Eskimos, and other peoples, such, for instance, as the Relationship System of the Vandau, the Designs of Alaskan Needlecases.

The author says in his preface that he hopes that collected writings will prove the validity of his point of view that the dynamics of life are of greater interest than the description of conditions. It is a book for the specialists.

—E.R.D.

MENKIN, VALY. *Dynamics of Inflammation.* New York: The Macmillan Company, 1940. 244 p. $4.50.

This is one of the Experimental Biology Monographs or biological essays by an active worker in the field of biology, being an inquiry into the "Mechanism of Infectious Processes." Inflammation or tissue reaction in the presence of certain irritants, is considered the physical basis of infections. For this reason, the students of diseases have throughout the ages considered it as the keystone to a proper understanding of pathology. Its importance in immunity and resistance is therefore obvious.

The purpose of the Biology Monographs is not only to present factual summaries of recent advances in research work but also to show the broad bases and theoretical implications of such advances. This book compiles observations gathered largely within the last decade. On the basis of this data, the author tries to formulate a dynamic concept of inflammation and to clarify and revise earlier interpretations. This authoritative presentation of cellular irritability will be welcomed by those who work in the fields of physiology, biochemistry, and immunology. The book is illustrated by a number of fine colored plates as well as statistical charts and tables.

—Greta Oppe.

LATIMER, W. M. AND HILDEBRAND, J. H. *Reference Book of Inorganic Chemistry.* New York: The Macmillan Company, 1940. 563 p. $4.00.

This outstanding book should be available in every chemical library. While most usable by college students, much of it is within the field of the high school student. I know of no place where students can find as much valuable data in descriptive inorganic chemistry as easily as here. The number of important facts in the field of atomic and molecular structures, bond

distances and energies are included, and all is in line with the newer discoveries in nuclear physics. Common and uncommon equations of the common elements and their compounds are given. There are tables of physical properties, electron structures, solubility products, crystal form types, oxidation and reduction potentials in the voluminous appendix. There is a glossary and a complete scheme for qualitative analysis. Although the book is not of the textbook type, it has more factual material, probably, than the average text, and lends itself to any organization that the instructor may wish to try out.

—W.G.W.

Osborn, Herbert. *Meadow and Pasture Insects.* Columbus, Ohio: The Educator's Press, 1939. 288 p. $3.75.

This is a scholarly work on a group of farm pests, stressing basic ecological principles of entomology. It is written with special reference to American Agriculture, thus describing and discussing many insect pests with which we are familiar. Mr. L. O. Howard describes the author as the "dean of the entomologists of North America."

The first part of the book discusses the ecology of insects, then meadow, then the animal groups of the meadow fauna, and general control measures for meadow and pasture insects. The following 200 pages are then devoted to the various insect orders with descriptions of the various members, scientific and common names, habits, appearances and so on.

Biology teachers in secondary schools and colleges as well as entomologists will find this a very practical guide and reference book.

—C.M.P.

Demaison, Andre. *The New Noah's Ark.* New York: The Macmillan Company, 1940. 294 p. $2.50.

This fascinating book translated from the French by Eric Sutton takes the reader adventuring in an old schooner along the African coast from Gaboon to Guinea. Here our autobiographical hero finds and cares for a varied animal population and a motley crew. Demaison spent many years in these parts he describes so well and the reader gets a good picture of the veteran trader of the Ivory coast and the native animal dealer.

Even when the schooner is wrecked and the animals escape, the hero does not complain. He has realized his boyhood dreams and lived his grandmother's fables of the fireside. Furthermore, Dame Fortune smiles upon him as he stains his hands with the brilliant black sand in the dazzling white of the sand dunes. The reader leaves him filling a sack with this precious deposit which he has recognized as titanium.

—Greta Oppe.

Millikan, Robert A. *Cosmic Rays.* New York: The Macmillan Company, 1939. 134 p. $2.50.

Doctor Millikan has succeeded in presenting in a clear manner the discoveries and investigation of cosmic rays. The average physicist will find in this book enough information to give him more than a talking acquaintance with the new discoveries and interpretations in the field. Millikan presents, without bias, the issues that have arisen in the study of cosmic rays even though, in many cases, his interpretations were not accepted. For graduate students, the book is an excellent example of the application of the scientific method. The tenacity of scientists to problems is exemplified, beginning with the early discoveries by Gockel and Hess and extending to the systematic studies by Compton, Clay and Millikan. The development of theories from the simple to the complex and the construction of apparatus from the crude to the refined is traced carefully. Millikan does not hesitate to give elementary explanations when he deems them necessary. The book contains several epoch-making cloud chamber photographs. This excellent history of cosmic rays is supplemented by a generous number of references to the original literature.

—Herman Roth.

Udmark, John Andersen. *The Road We Have Covered.* New York: Modern Age Books, 1940. 361 p. $3.50.

The author of this book has resided in America, mostly in the United States, since 1906 when he was seventeen years old. As one of a large family of Danish children, he could not satisfy his early ambition for priestly education. Therefore, he came to America, of which he now says: "America was once the land of opportunity. It is so no more. It can never be so again in the old sense." One feature of his present environment is suggested by the copyright page which says that the book was "edited and produced" by contract with one of the major labor organizations, and "printed and bound" in shops of the other major labor organization. To those who read the book it will appear that the intelligent discouragements of the author's early years have widened and deepened during the extensive studies of his subsequent years. The "way out" which he proposes in his closing chapter, "The Road Ahead," will interest all thoughtful readers, though many, possibly most, will scarcely believe in the practicality of the proposals.

There are thirteen chapters. Their range in themes is from the formation of the earth, through man's appearance, early development, organizations for gaining and holding dominance, religion and politics, personal ownership and governmental control, the development of ideals of morals, the accompanying flood of crimes and the futility of imposed punishments, the achieve-

ments of science in relation to welfare of individuals and to the government and to war and peace. Throughout the book there runs the theme which this reviewer characterizes as the development and subsequent inhibiting influence of personal, group and national habits, customs, regulations, institutions, and economic controls. Of course such developments had to occur to avoid utter chaos. But the author wisely sets forth the stupefying effect of failure to keep such developments constantly developing in terms of new social needs. There must be accepted regulations, but unchanging obedience to unchanging regulations produces a stagnant society. The founders of the Constitution were radicals in their day. In retrospect they are conservatives. Each generation needs its own radicals, not rabble-rousers, who always intelligently urge steps forward, always urging changes in the *status quo*, upon the basis of evidence of social needs.

This book has very wide perspective. Its author writes from an astonishing compass of modern knowledge. Whether we agree in his conclusions as to the things now needed, all would be helped by study of the considerations here presented.

—Otis W. Caldwell.

DODD, JAMES HARVEY. *Introductory Economics.* Cincinnati: South-Western Publishing Company, 1940. 596 p. $1.60.

In the midst of the current attempts to set up new organizations of materials in social studies for secondary schools, there are relatively few texts in organized special subjects. The present volume on economics is one of the few. It is a revision of the author's earlier book in the same field.

The book is definitely of senior level and might serve equally well in many junior college situations.

The eight major parts serve as unit organizations for the course, although these are not designated as units. These parts are: why do we study economics; how is wealth organized and managed; how do goods reach consumers; what determines prices; what are money and credit; what problems arise in distributing national income; what is the place of government in modern life; how can the people in the nation achieve the highest degree of well-being. Part seven deals with desirable and undesirable forms of taxation. Part eight includes a treatment of social security and a chapter defining capitalism, socialism, communism, and fascism.

The book is specifically a school text and not well suited to the needs of the lay reader nor of great general value for libraries. It is recommended for the consideration of senior high school teachers seeking a textbook in economics.

—R.K.W.

SHIELDS, H. G., AND WILSON, W. HARMON. *Consumer Economic Problems.* Cincinnati: South-Western Publishing Company, 1940. 767 p. $1.88.

The typical adult consumer will be much concerned with this new text in business education. The units deal with the more pressing problems of personal and home expenditures. Enough basic interpretation of the business world and of principles of economics is integrated with the working out of the unit problems to give the whole a sound structure. The book is no popular treatment of superficial interest to the casual reader but a summarized culmination of the training in business education in the modern high school.

The chief criticism may well be in the fact that the consumer problems treated are those of the trained and experienced adult rather than those of the adolescent now being trained in the secondary school. The problem of training for adult and deferred values will continually confront the teacher working with this book as a text.

The book is recommended for the consideration of teachers of business education. It seems more suitable to the needs of seniors in high schools or students in junior colleges than to younger pupils.

If this book can be called to the attention of adults interested in consumer problems, it may well fill a gap in the books available for general reading in consumer education.

Teachers of courses in home economics may well call this volume to the attention of their students.

The book is accompanied by a well done teacher's manual, a workbook for pupils, and a set of unit tests. The exercises of the workbook are chiefly of the problem type. The teacher familiar with the type of material often used in secondary school accounting courses will be on familiar ground with many of the suggested exercises. The sequence of text, workbook, tests, and teacher's manual will furnish a rather complete kit of working tools to the busy teacher of a senior high school course in business education.

—R.K.W.